

Is water flowing on Mars? SEE PAGE 66

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June 2004

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VENUS crosses the Sun

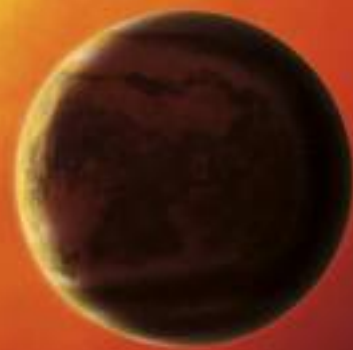
How you can view this super-rare event

**The planet that
shouldn't exist**

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ever be dark again?**

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How rare is it? No living person on Earth has seen a transit of Venus.

LX200GPS

10 REASONS WHY YOU SHOULD BUY A MEADE SCHMIDT-CASSEGRAIN:

1. Meade Ultra-High Transmission Coatings (UHTC™) Group* increases total light transmission and image brightness by nearly 20% over Meade standard coatings.

MEADE EXCLUSIVE

*Available as an option only at time of purchase.

2. Optical System – Meade utilizes water white glass as standard equipment in all 8", 10", 12", and 14" Schmidt-Cassegrain corrector lenses (UHTC and standard coatings) to maximize light transmission. The use of water white glass results in an increase of light transmission in excess of 10% as compared to telescopes using green soda lime glass.

MEADE EXCLUSIVE

3. Zero Image-Shift Microfuser allows the user to obtain precise image focus with no image movement. Operates at four different speeds from the Autostar II handbox.

MEADE EXCLUSIVE

4. Primary Mirror Lock locks mirror in place during long-exposure photography.

MEADE EXCLUSIVE

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MEADE EXCLUSIVE

6. 16 Channel GPS Receiver with true-level sensor automatically inputs precise time, date, and geographical location to help quickly and precisely align and level the telescope.

MEADE EXCLUSIVE

7. Oversize Primary Mirror diameters are greater than their listed aperture (e.g., the diameter of the 8" LX200GPS is actually 8.25"). This additional 1/4" yields a fully illuminated field-of-view which is significantly wider than is possible with standard size primary mirrors. The result is that Meade's Schmidt-Cassegrains have brighter off-axis field illuminations (aperture-for-aperture) than Schmidt-Cassegrain telescope systems using non-oversized mirrors.

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8. Smart Mount™ * constantly refines pointing accuracy each time an object is centered and updated. Compatible with equatorial and altazimuth mounts.

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*Can be purchased as an upgrade for older LX200GPS telescopes for only \$99.

9. Autostar Update keeps your Autostar controller up-to-date with the latest software upgrades, guided tours, and timely objects like comets.

MEADE EXCLUSIVE

10. Meade Autostar II handbox controller features "Hot Keys" for quick access to a 145,000 celestial object database.

MEADE EXCLUSIVE

Manufactured under U.S. Patent Nos. 6,304,376, 6,392,799 and 6,563,636; other patents pending in the U.S.A. and worldwide.

14" LX200GPS-SMT

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meade.com

Suggested U.S. national mail-order retail prices for LX200GPS-SMT models:
7" – \$2695; 8" – \$2195; 10" – \$2745; 12" – \$3595; 14" – \$4995

Packing & shipping charges in the 48 states:

8" LX200GPS-SMT – \$105; 10" – \$145; 12" – \$215; 14" – \$265; 7" – \$125.



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A publicly-traded, employee-owned company (NASDAQ symbol: MEAD)

LX90

MEADE

8"

LX90

THE TELESCOPE OF A LIFETIME

Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum double-tine fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for about 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — the same tripod provided with Meade LX200GPS models.

With diffraction-limited optics in an Autostar computer-controlled telescope system, the Meade 8" LX90 includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is fully qualified for long-exposure CCD imaging and astro-photography as well as for other advanced photo-visual applications.



8" LX90
Schmidt-Cassegrain
\$1695

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

Autostar™ Computer Controller: The LX90's standard-equipment Autostar controller permits an incredible array of telescope features:

- Automatic GO TO capability at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
 - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- Automatic GO TO capability to any object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- Nine selectable slew speeds: 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- Control of the telescope through your personal computer. (Requires optional #505 Connector Cable Set.)
- Fast alignment of the telescope using any of three alignment functions, including the Meade-proprietary Easy Align.
- Autostar is fully upgradeable over the Internet: add the positions of new comets, update the positions of Earth satellites, even add new software.

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF₂ coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **\$1695.**
Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%; add **\$175.** Packing & shipping in the 48 states: **\$95.**

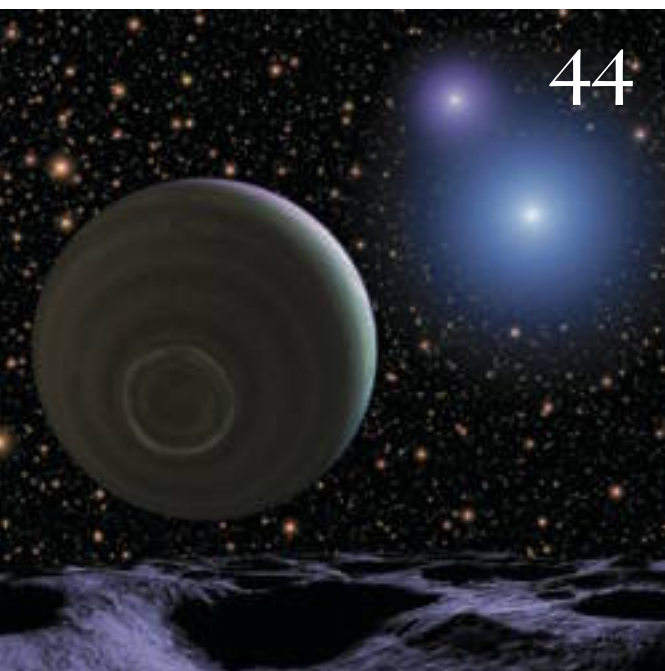
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Included with LX90:
Meade Autostar Suite™ including LPI™ imager
A \$149 value!



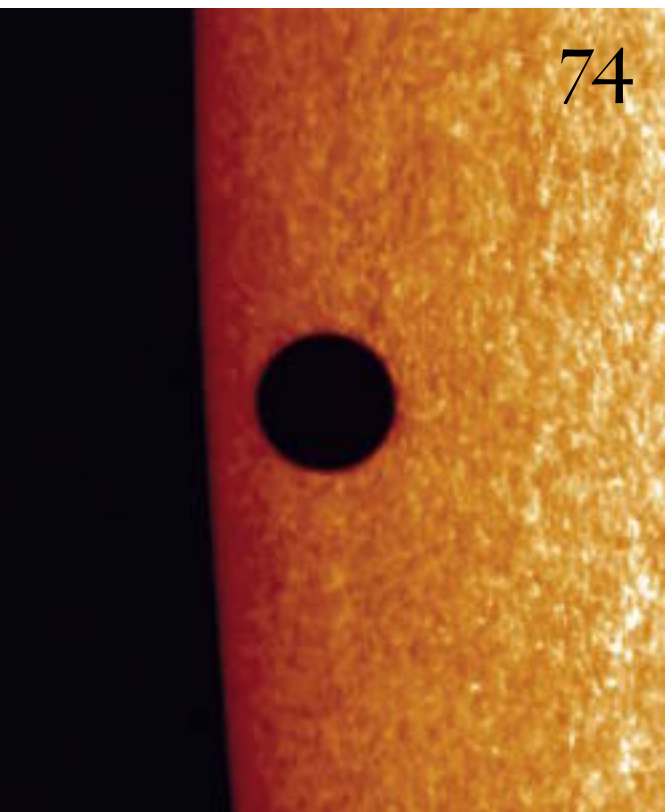
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June 04



44

ADOLF SCHALLER



74

ROYAL SWEDISH ACADEMY OF SCIENCES

features

COVER STORY

32 Chasing the shadow of Venus | ☿

Among the rarest of celestial events, transits of Venus have enticed generations of astronomers seeking to measure the scale of the solar system.

RAY JAYAWARDHANA

AMATEUR ASTRONOMY

38 Reclaim the night sky | 🌌

A night sky made bright by artificial light is a fact of life for most skygazers in North America and elsewhere. Yet if backyard astronomers work with their communities, it's possible to combat this problem. MICHAEL E. BAKICH

GALACTIC ASTRONOMY

44 Genesis planet | 🌌

Astronomers are starting to think planets, and maybe even life, gained a foothold far sooner than previously believed — perhaps less than a billion years after the Big Bang. RAY VILLARD AND ADOLF SCHALLER

PLANETARY SCIENCE

66 Does Mars have flowing water? | 🌌

Dark streaks by the thousands run down the sides of valleys and craters on the Red Planet. Planetary scientists say they're dust avalanches, but could any of the streaks be caused by water seeps or springs? TÁHIRIH MOTAZEDIAN

SOLAR SYSTEM OBSERVING

74 Viewing Venus in transit | ☿

For the first time in 122 years, Earth's neighbor will cross the face of the Sun. Here's all you need to know to view this exceptional event.

MICHAEL E. BAKICH

ASTROPHOTOGRAPHY

78 Amateur CCD discoveries | 🌌

When the first CCD cameras for amateur astronomers were introduced in the early 1990s, great excitement followed. After a decade of imaging thousands of celestial objects, what have amateurs contributed to the science? More than you might think. JACK B. NEWTON

TRAVEL

84 A visit to Mars Hill | 🌌

The Lowell Observatory in Flagstaff, Arizona, offers something for the history buff and active observer alike. The exciting plans for the future of this observatory complement its renowned legacy. DAVID HEALY

departments

06 This month in Astronomy

Astronomy's big, rare event

10 Letters

12 Bob Berman's strange universe

Venus puts on a show

14 Glenn Chaple's observing basics

Safely viewing the Venus transit

16 Interview

William K. Hartmann, senior scientist,
Planetary Science Institute

22 News

- Swirling echoes of light
- "Maybe" to the Moon this year
- Ice near Mars's equator
- Hubble's ultra-deep stare
- Supernova 1987A's pearly ring

50 The sky this month

Venus transits! Comets rule!

MARTIN RATCLIFFE AND ALISTER LING

70 Ask Astro

Cosmic conundrum, stellar fingerprints,
rocket science

90 New products

- Herald-Bobroff *AstroAtlas*
- Ideal Astronomy's SightSaver
- TMW Media's *Astronomer* video
- Space.com's *Eyes on Mars*

92 Book reviews

- *The Cambridge Encyclopedia of Amateur Astronomy*
- *The Moons of Jupiter*

94 Coming events

95 Advertiser index

96 Resources

102 Reader gallery

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discoveries made at Lowell Observatory.



ON THE COVER

One of astronomy's rarest events takes place this month: a transit of Venus. The last time Venus's black disk traveled across the face of the Sun, the year was 1882 and Chester A. Arthur was president of the United States. This time, telescopes in Europe, Africa, and Asia will show the entire six-hour transit. Eastern North Americans will see the last portion of the event. ASTRONOMY: ROEN KELLY

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Astronomy's big, rare event

It's simple, really, but few things in astronomy transfix enthusiasts as much as a transit of Venus. The disk of our sister world gliding between Earth and the Sun makes a tiny black dot move across the face of our star. The last time it happened was 1882; no one alive has ever seen this super rare event. On June 8, 2004, the world will

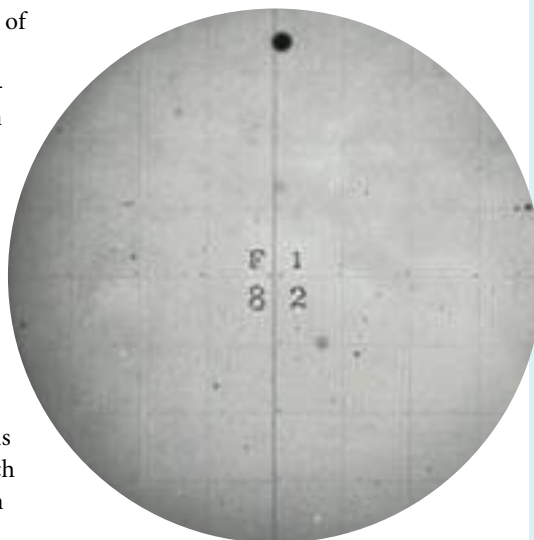
again witness this incredible coincidence of our solar system's orbital geometry.

"There will be no other till the twenty-first century of our era has dawned upon the earth," wrote U.S. Naval Observatory astronomer William Harkness in 1882, "and the June flowers are blooming in 2004." Now that time has come, and legions of amateur astronomers are looking forward to watching and photographing this transit.

The best places to see the transit from will be Europe, Africa, and Asia, and *Astronomy* is leading two expeditions to view the transit — one to Egypt, which I will accompany, and the other to South Africa, which associate editor Michael Bakich will attend. We are working with our travel partners, Vic and Jen Winter of Astronomical Tours, and Roy Mayhugh of Mayhugh Travel, to bring these adventurous trips to you, and we will report on them in a future issue.

The transit lasts for several hours. Its beginning will be visible from Japan, Indonesia, the Philippines, and Australia, where the Sun will set before the event ends. Observers in eastern North America, the Caribbean, and most of South America will see the end of the transit.

For an enticing historical and scientific story of what the transit of Venus means to astronomers, see "Chasing the shadow of Venus" by University of Michigan astronomer and award-winning writer Ray Jayawardhana on page 32. The other half of our special coverage begins on page 74, where you will find Michael Bakich's story



A RARE 1882 PLATE captures Venus in transit across the face of the Sun. U.S. NAVAL OBSERVATORY

"Viewing Venus in transit," which tells you how to observe and photograph the event.

Please also read Bakich's story on the war against light pollution, "Reclaim the night sky," beginning on page 38. I encourage you to read it carefully and to contact the International Dark-Sky Association, whose address is in the article, to find out how you can help keep our skies dark for the future of astronomy.

Yours truly,

Dave Eicher
Editor

70 • 90 • 105 • 125

ETX

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The telescopes that have revolutionized amateur astronomy are now available with Autostar® and Field Tripod at very special low prices!

Matchless diffraction-limited optics: *Sky & Telescope* described ETX-90 optics as “excellent...stellar diffraction patterns were virtually textbook-perfect...the Cassini Division in Saturn’s rings popped into view despite the rings’ low tilt...Epsilon Lyrae’s component stars were cleanly split...the Moon was beautiful at any magnification, with black shadows contrasting sharply with illuminated features along the terminator...the mechanics of the optical tube assembly are also first rate.”

A long listing of standard-equipment features including rigid fork mounts; dual-axis drive systems with high-torque DC motors on both telescope axes; cordless field operation from eight (user-supplied) AA-batteries that power the telescope for more than 20 hours of normal usage; and internal flip-mirror system for observing or imaging from either the 90° or straight-through positions.

#497 Autostar Controller: The patented Meade Autostar controller brings automatic GO TO operation, plus dozens of additional menu options, to your fingertips, with a database of more than 30,000 celestial objects, including 5,386 galaxies, nebulae and star clusters from the Index Catalog (IC); 7,840 objects from the New General Catalog (NGC); 110 Messier objects; the major planets from Mercury to Pluto; and more.

#884 Deluxe Field Tripod: Constructed of strong, lightweight steel, the full-length Meade #884 Deluxe Field Tripod provides a rigid mounting platform for virtually any ETX observing application. Tripod height is adjustable for seated or standing observing. Use in either equatorial or altazimuth orientations; a graduated scale permits precise polar alignment. For Autostar applications, or for terrestrial observing, the tripod locks to 90°.

Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

ETX-90AT Astro Telescope \$595
ETX-105AT Astro Telescope 795
ETX-125AT Astro Telescope 995

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%:
 ETX-90AT— \$50; ETX-105AT— \$75; ETX-125AT— \$95

Alternately, for the beginning-to-intermediate observer, the ETX-70AT is supplied with #494 Autostar Controller and #882 Field Tripod:

ETX-70AT Astro Telescope 299

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — \$30; ETX-105AT — \$35;
 ETX-125AT — \$40; ETX-70AT — \$20.



Meade ETX-125AT
 Shown with standard-equipment
 #497 Autostar Controller and
 #884 Deluxe Field Tripod.

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premium accessories

FEATURED PRODUCT

Meade NightView™

NEW!



Gone are the nights of stumbling around the star party with a red flashlight. You'll no longer trip over tripod legs or ruin your astrophotos. If you drop your eyepiece or a thumbscrew, use NightView to find it. NightView comes with three filters, including a red filter, so you won't lose your dark adaptation. NightView makes obsolete those old, fuzzy, green images of competing night vision devices. Meade's NightView features state-of-the-art digital imaging technology which yields a crisp, contrast-rich image, in all low-light, and even no-light conditions. It makes a great gift for the avid astronomer, or outdoor enthusiast.

- Features 2X digital zoom
- Includes red, green, and neutral filters
 - Red: Preserves your night vision.
 - Green: Can see the greatest detail.
 - Neutral: Minimizes the amount of light to the eye.
- Can be used in all light conditions without damaging the sensor.
- Easy-to-use and compact.
- NightView can be attached to any standard tripod. It can also be connected to a monitor or camcorder for surveillance.

\$299.00 (8.49)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify #927 (.965"), #928 (1.25"), or #931 (fits .965" focuser, accepts 1.25" eyepieces). **\$42.95** (3.86)



2" Diagonal Mirrors with UHTC

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. #930: Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders. #929 or #930, each: **\$119.95** (6.85)



Series 4000 Nebular Filters—Premium multi-layer interference filters. Broadband ("B") filters block most forms of light pollution; narrowband ("N") filters are for heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B—Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)

#911B—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)

#908N—Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)

#911N—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)



Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X—Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)

#911X—Threads on to rear cell of Schmidt-Cassegrain telescopes; 36mm dia. **149.95** (5.26)

Series 4000™ Super Plössl 52° field; multi-coated

4-element Super Plössl general-purpose eyepieces for observing lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space; unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers. Multi-coated. All focal lengths through 32mm are parfocal. **Super Plössl** (SP; 4-elements; 1.25"; 52°): 6.4, 9.7, 12.4, 15, 20, 26mm each: **\$79.95** (4.54); 32mm (52°); 40mm (44°) each: **99.95** (5.26); 56mm (52°; 2") **199.95** (7.02)



Series 4000™ Super Wide Angle 67° field; multi-coated



Exquisite wide-angle images, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. **Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)—13.8mm: **\$139.95** (4.54); 18mm: **149.95** (4.54); 24.5mm: **179.95** (5.26); 32mm (2") **239.95** (7.02); 40mm (2") **299.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated



The ultimate eyepieces; extreme image sharpness over an amazing 84° field. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)—4.7mm: **\$169.95** (5.26); 6.7mm: **199.95** (5.26); 8.8mm (1.25"/2") **239.95** (7.02); 14mm (1.25"/2") **299.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images unmatched resolution, contrast and color correction. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **\$79.95** (5.26)



2x Short-Focus Barlow (1.25")

#126: 2.5" long, works with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **\$47.95** (4.54)



Series 4000 Photo-Visual Color Filters (1.25")—Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue — each **\$14.95** (2.73)

Set #1—4 filters: #12, #23A, #58, #80A **49.95** (4.54)

Set #2—4 filters: #11, #25A, #47, #82A **49.95** (4.54)

Set #3—4 filters: #8, #21, #38A, #56 **49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **\$16.95** (2.73)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing with eyeglasses. Internal zoom lenses move on smooth, precisely-machined tracks. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **\$219.95** (6.38)



Series 4000™ f/6.3 Focal Reducer/Field Flatteners

Threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **\$129.95** (5.26)



Series 4000™ f/3.3 CCD Focal Reducer/Field Flatteners

3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and reduced CCD exposure times. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to f/3.3 and f/6.3 SCT's to f/2. Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **\$149.95** (5.26)

HOW TO ORDER:

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in () next to each price. The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:

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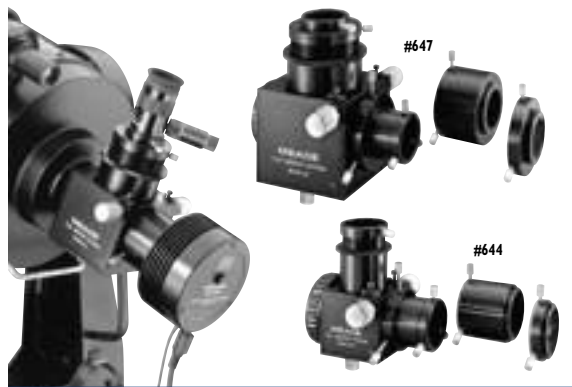
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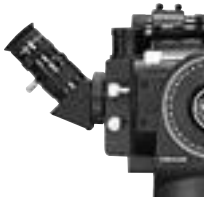
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Preservation efforts

I'd like to add my voice to the crowd that wants to save the Hubble Space Telescope. I'm Canadian but proud of my neighbors for the effort they have put into their space program. We have helped as well. If space exploration keeps up at the pace it has until now,



THE HUBBLE SPACE TELESCOPE imaged dwarf galaxy NGC 1569 through ultraviolet, green, red, and hydrogen-alpha filters to create this composite. ESA, NASA, AND P. ANDERS [GÖTTINGEN UNIVERSITY GALAXY EVOLUTION GROUP]

then in thirty years, we will have casual commercial traffic to low-Earth orbit. Any resource there will have commercial value.

I'm an armchair astronomer; I own a telescope but don't take it outside very often. My binoculars get more use, but my main telescope is my computer screen. But if someone offered me the mirror in the Hubble, I'd take it, flawed as it is.

I suggest the United States run the Hubble as long as they can and then donate it to amateur astronomers. If they have to send up an unmanned vehicle to deorbit it, it would be just as easy to boost it up into a parking orbit. Then, give it to an amateur astronomy society set up for sharing its data. It might take them twenty years to build a scope around it, but they'll find a way. Why throw it away?

— ALAN MADILL, VANDERHOOF, BRITISH COLUMBIA, CANADA

Keep the shuttle

What a waste it would be to lose the space shuttle prematurely. What are the odds there would be a similar or different problem that downed our last shuttle? Does it really make sense to skip the last servicing mission to the Hubble Space Telescope? I hope something will be done to change the minds of the powers that be so we do not lose one of our most wonderful space tools so unnecessarily. — JOHN METRO,

EDGEWATER, FLORIDA

The southern sky

On page 110 in "Reader gallery" (January 2004), it states southern stars go "the wrong way" when they rise, curving to the upper left. This is true only if an observer is facing north. If you face south, stars rising in the east will move from the east to the west, curving to the upper right.

This happens because you're looking at the stars moving clockwise (opposite the movement of stars around Polaris) around the "South Star" (Sigma [σ] Octantis). Thus, they rise in the east.

For a northerner, observing in the Southern Hemisphere can be a bit confusing. One of the weirdest things I saw in Australia was a 3-day-old Moon on the wrong side of the sunset point! Seeing northern constellations upside down while facing north was a bit disconcerting, too.

Perhaps the biggest surprise for me was seeing the Big Dipper from Australia. In March–April of 1986 on a Halley's Comet tour in Alice Springs (latitude -23.5°), I watched as the dipper reached its highest point above Polaris (which was invisible) and could be seen briefly skimming the northern horizon. — BILL DELLINGES,

APACHE JUNCTION, ARIZONA

Field report

A group from the Fort Wayne Astronomical Society, while in New Mexico this past September, put our scopes aside and rented JMI's RB-66 for a night. We all agree with Phil Harrington's assessment of the binoscope's spectacular seeing in the night sky (see *Astronomy*, February 2004).

We concluded, however, it's a product best used by a lone astronomer. Each time we would change observers, we had to adjust the interocular distance, which called for each 6-inch tube to be individually refocused. This proved to be time consuming over a night of observing.

But when it was over, we also all concluded it had been very worthwhile to have observed through JMI's RB-66. — RON KERR, FORT WAYNE, INDIANA

We welcome your comments. Send letters to *Astronomy Letters*, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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The last big one

The main difference between humans and animals is *we're* not afraid of vacuum cleaners.

And, dividing things further, the main difference between astronomers and everyone else is *we're* not bored by faint blobs and tiny dots. ☾ A long-awaited black dot will cross the Sun's face on June 8. Those in the eastern half of the

United States get to see the Venus transit if the rising Sun is in the clear, provided they use a solar filter to keep their retinas from becoming black-fried — Cajun style.

When I was a kid, I longed for Comet Halley's return in the far-future of 1985 and ached to see a great aurora and a total solar eclipse. Well, like so many of us, I've been blessed with observing these infrequent wonders, and now only one remains — the Venus transit, the last of the biggies and the rarest of them all.

Unless you're a total math-o-phobe, you gotta love its rhythm. The tilted orbits of Venus and Earth are misaligned by 3.4°,

node 105.5 years later to yield a pair of 22nd century December transits. The transit cycle is, therefore, 121.5 years, 8 years, 105.5 years, 8, 121.5, and so on.

It's hard to think of a rarer celestial event. Nobody now alive saw the last Venus transit in 1882. Total solar eclipses average one per 360 years for any given location, but those willing to travel can see one almost every year.

A great aurora? Rare from Mexico City but not so uncommon in the upper half of the United States. A meteor storm qualifies — but we get one or two per century. Halley is a once-every-76-years event, but

ble to obtain a proper solar filter beforehand, such as a #14 welders' filter, and *if* he sets the alarm for five o'clock that Tuesday morning, and *if* he then drives to a spot with a perfectly unobstructed northeastern horizon — *if* he really does all that, he'll see a tiny black speck that will occupy just $\frac{1}{1000}$ of the Sun's face. If any large sunspots are present, Joe will wonder which is Venus. He'll be confused, sleepy, and irate. This won't be a good time to borrow money from Joe.

I've waited more than forty years for this, but I'm not going to oversell it to my friends, or to you. When contacted by the media for a comment, I'll emphasize its rarity and the historical role transits played in bygone centuries for determining the distance to the Sun. But if we then suggest people can witness a knockout visual spectacle, we'll be like those web sites that proclaim "see a sky filled with meteors tonight!" when it's a minor shower and the Moon is bright. Why serve up confusion or

Even monkeys notice eclipses; and I've watched prison inmates stare at a great comet. A meteor storm instills awe — sometimes fear.

so Venus partially eclipses the Sun only when the planet reaches inferior conjunction just as it arrives at one of the nodes where our paths cross. The last time that happened was 121.5 years ago. But once it does happen, an oddity enters the picture. Because Venus circles the Sun thirteen times just as Earth circles eight times minus a couple of days, a direct hit on a node follows just 8 years later. The current June 8 transit enjoys an encore performance on June 6, 2012, and that one will be seen from *everywhere* in North America.

After that, inferior conjunctions every nineteen months slowly creep around Venus's orbit until reaching the opposite

great comets come along every 15 years on average. A Venus transit, obviously, is rarer than all of these.

But there's a big difference between "rare" and "spectacular." Those other rarities also happen to take one's breath away. You don't have to be an astronomer to be amazed. Even monkeys notice eclipses, and I've watched prison inmates stare at a great comet when Hale-Bopp came by a few years ago. A meteor storm instills awe — sometimes fear.

A transit is a different animal. Astronomers will love it, of course. But we'd better not oversell it to the general public. *If* your average Joe actually takes the trou-

disappointment to a public that already suspiciously regards astronomy as a hit-or-miss pastime? Present the transit honestly and there'll be no problem.

Anyway, *we'll* have a feast. Venus, the largest-looking planet, will hover at its normally invisible near-point and measure 1' across — making it possible to appear as a disk rather than a point to the naked eye. If the weather is humid enough that the rising Sun looks deep red (but *only* then), a quick direct look without any filter should be safe (but *never* through binoculars or a scope). It's a one-time chance to see the disk of a planet with the naked eye alone.

And that's fun? Sure. For you and me. ■



actual screen view

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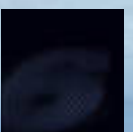
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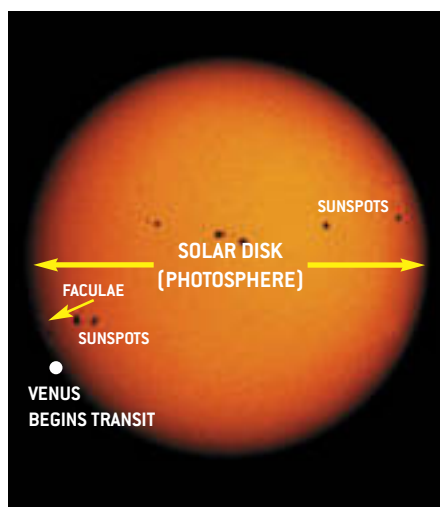
As you know, the big event this month — one of the biggest astronomical events of the century — is the transit of Venus across the face of the Sun on June 8. Whether or not the transit will be visible from your locale, knowing how to view the Sun safely is a skill you'll want to master. Even without a headline-grabbing

event like a transit or solar eclipse, the Sun is a fascinating telescopic target.

You don't have to be reminded that viewing the Sun is risky business — especially when a telescope is involved. Besides the obvious damage to your eye, there's always the possibility that the heat and light your telescope collects could ruin a good eyepiece, not to mention a good eye.

The safest way to get a close-up view of the Sun is by eyepiece projection. This method is ideally suited for a small-aperture telescope with a low-power Ramsden or Huygenian eyepiece (look for an "R" or "H" stamped on the eyepiece). Each of these simple eyepiece designs uses two widely separated glass lenses — a setup that can withstand heat better than more complex eyepiece designs that use cemented optics. Solar heat can "cook" the cement and permanently cloud the view through such an eyepiece. Because even a small finder scope can collect an eye-damaging amount of sunlight, keep the finder capped and aim sunward using the shadow of your scope as a guide. When you see light coming out the eyepiece, you're on target. Hold or suspend a piece of white paper one foot from the eyepiece. The circle of light you see is the Sun's disk. Focus until the disk is sharp at the edges.

If you don't want to risk ruining an eyepiece or you simply prefer to view the Sun directly, you'll need a filter. Do not use an inexpensive solar filter that screws into the eyepiece. I shudder to think of those occasions years ago when I used a screw-in solar filter to show school children the Sun



VENUS TRANSITS the Sun on June 8. At 1:14 A.M. EDT, the disk of Venus will look like it is touching the edge of the Sun. *ASTRONOMY: ROEN KELLY*

through my telescope. Little did I know that heat buildup at the eyepiece could have cracked or shattered that filter suddenly with disastrous results. Direct solar viewing is safest when you use an aperture filter that attaches to the front of the tube and filters sunlight before it enters the telescope. Aperture filters tend to be a bit pricey (typically \$50 to \$100 or more for one that fits a small-aperture scope), but they're worth it. Check the ads in this magazine for reputable companies that offer aperture filters.

What can you expect to see when you aim your telescope sunward? The first thing you'll notice is the solar disk, which appears slightly darker near the edge. This visible surface of the Sun is called the pho-

tosphere. If the photosphere appears somewhat grainy, it's not the fault of your telescope. This granulation results from rising and falling masses of gas on the seething cauldron that is the Sun's surface.

The most interesting solar features are sunspots which, as the name implies, appear as dark blotches. If you observe the Sun on consecutive days, you'll discover that a sunspot is an ever-changing transient phenomenon that can last as short as a day or two or remain visible for months. From day to day, sunspots appear to drift across the disk of the rotating Sun. Those sunspots near the limb of the Sun often are accompanied by light patches called faculae, which are regions of activity above the photosphere. Be aware that the Sun is approaching the quiet phase of its 11-year sunspot cycle. If you see a "clean" solar disk today, try again in a few days.

Good luck, and clear skies to those of you with a shot at seeing the Venus transit. If you're out of the transit zone, don't worry. You'll get your chance in 2012. In the meantime, go out and pay your respects to "old Sol." Anyone who puts his telescope away at the dawn's early light is missing some exciting viewing.

A year ago in this column I discussed the temperature-color relationship in stars. Hot stars tend to be blue or white, while cooler stars shine in shades of yellow, orange, or red. Al Aburto, of San Diego, California, e-mailed to ask why there are no green stars. Interesting question, Al. Because green lies near the middle of the spectrum, stars that emit a preponderance of light in this color also produce similar amounts of light at either end of the spectrum. The result is a blend that appears white. For more on "heavenly green," see Bob Berman's column, "Space emeralds," in the March 2003 issue of *Astronomy*.

NEXT MONTH: We "get social" with a look at astronomy conventions; also, a visit to the Summer Triangle. Clear skies. ■

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 ProStar Dew Shields:	
ETX flexible	call
8" flexible	49
8" metal	129
10" flexible	59
10" metal	149
11" metal	169
12" flexible	79
12" metal	199

TeleVue

Telescopes (free S/H)		Nagler-82"	
NP101 w/3-6mm	3595	3.5mm T6	\$280
Plossl-51"		5 or 7mm T6	280
8, 11, or 15	\$82	9mm T6	280
20 or 25mm	95	12mm T4	355
32 or 40mm	110	13mm T6	280
Panoptic-68"		16mm T5	320
15mm 210 19mm 240		17mm T4	385
22mm 280 24mm 295		22mm T4	460
27mm 330 35mm 365		26mm T5	580
Radian-60"		31mm T5	620
3, 4, 5, 6, 8, 10, 12, 14, or 18	ea. 240	Barlows	
Diagonals		1.25" 2x or 3x	105
2" Everbrite	275	New 2.5x or 5x	190
1.25 Everbrite	190	2-inch 2x	198
		2-inch P-Mate	280
		2-inch 4x	295

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William Hartmann

A celebrated scientist, writer, and artist, Planetary Science Institute senior scientist William K. Hartmann's love affair with the universe takes multiple forms. His paintings of celestial scenes have graced the covers of magazines and renowned gallery spaces across the world. He's penned a sci-fi novel about Mars; an historical

novel about Spanish conquistadors in the desert southwest; and most recently, a planetary overview, *A Traveler's Guide to Mars*. For him, conventional boundaries of time and space hold little sway as past, present, and future fuse into an archetypal amalgam of inquiry, idiom, and imagery.

In 1997, Hartmann won the Carl Sagan medal of the American Astronomical Society for communication of science to the public. He is also credited with initiating the widely held notion that the Moon was born out of a cosmic collision between primordial Earth and a planet-size body.

Today, from his office in Tucson, Arizona, Hartmann mines for truth about Mars in the vast data reserves of the Mars Global Surveyor spacecraft and is a leading voice in the push for human exploration of the Red Planet.

Are we ready to send humans to Mars?

Yes. Technically, we could start now. We understand problems like radiation shielding and spacecraft spinning to produce gravity. But I'd like to see a Mars program tied to *larger* goals.

The problem I see as a planetary scientist, backing off and looking at Earth from a distance, is that we are divided into nations warring to control the last reservoirs of fossil fuels and ores. We've reached the point of affecting Earth's climate. An international Mars program could help us all learn to deal with such global issues. Rather than just land on Mars, we need to look at what we can discover on the way.



WILLIAM HARTMANN believes we can learn many things about Earth while developing a plan to send humans to Mars. AMY HARTMANN

Such as?

We're surrounded by an abundance of free solar energy, not to mention metals and other resources to be found in asteroids. When do we start learning how to explore those resources and hand that capability down to our grandchildren? Space exploration offers that option, and historically, it has offered a role model for developing cost-sharing international approaches.

Why visit Mars?

To discover if life ever started there. If so, we're not alone in the universe. If not, maybe we're more alone than we thought. Either way, it's profound.

What's our responsibility to Mars and potential life there?

We have to be careful about how we handle human exploration of Mars. Too many dropped Kleenexes, so to speak, could contaminate the hypothetical martian water, aquifers, and environment. Some experts argue any microbial life on Mars is inferior to us, and therefore, we should not worry about overwhelming it with our own organisms. So, they say we should just go charging ahead gung-ho to establish bases and colonies on Mars without trying to find out first if the planet spawned life on its own. I think that would be a terrible mistake. Mars may be our only chance to learn if life started on another nearby planet, and we should apply our intelligence to figuring out how to answer that question.

Any advice for kids who want to be on that first spaceship to Mars?

Keep up your interest regardless of what your friends say. The kids with an interest and a dream will win in the long run. Ray Bradbury once talked about how everyone teased him for his interest in *Buck Rogers* comics. Years later, they came back to him to learn what *Buck Rogers* was all about.

Which was your first love — science, painting, or writing?

I suppose science came first, but really they're all wrapped up together. In Leonardo da Vinci's day, science and art were the same thing — ways to understand our relationship to the universe. Leonardo painted to learn about waves and clouds and studied anatomy to be a better painter.

Also, I think novelists can be scientists of the human soul. Most readers look to novels for escape, but there's also a tradition of using novels to examine issues, history, the future, and the human psyche. ■

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No Purchase Necessary. The official start date for the Astronomy Summer Sweepstakes is April 23, 2004. Official entry forms are bound in the June, July and August 2004 issues of Astronomy. The Astronomy Summer Sweepstakes is open to residents of the United States and Canada (except Quebec) only, 18 years of age or older. Employees (and their dependants and immediate household members) of Kalmbach Publishing Co., their advertising and promotional agencies, and participating sponsors are not eligible to participate.

Sweepstakes Entry. To enter, complete and mail the official entry form or a postcard with name, address, city, state or province, zip and telephone number on a postcard and sent it to: Astronomy Summer Sweepstakes, P.O. Box 378, Waukesha, WI 53187-0378. Or enter online at www.astronomy.com by filling in the Online Entry form and hitting the SEND key. The Online Entry form must be filled out completely to be eligible. Incomplete or defaced entry forms are void. One entry per household. The official ending date for the Astronomy Summer Sweepstakes is August 6, 2004, and all entries must be transmitted or postmarked no later than that date.

Prizes and Odds of Winning. One drawing will be held on or about August 30, 2004, for the following awards: One Grand Prize consisting of a NexStar 11 GPS Telescope (retail value \$3,000.00). Two First Prizes consisting of a NexStar 8i Kit (Telescope, Tripod, Computer Hand Control) (retail value \$2,150.00). Three Second Prizes consisting of a NexStar 80 GT Telescope (retail value \$616.67). Four Third Prizes consisting of a SkyMaster 15x70 Binoculars (retail value \$125.00). Cash equivalents of merchandise will not be awarded. Substituting prizes is not allowed. Any applicable federal, state and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for Astronomy Magazine is 155,064. Sweepstakes void in Quebec and void where prohibited.

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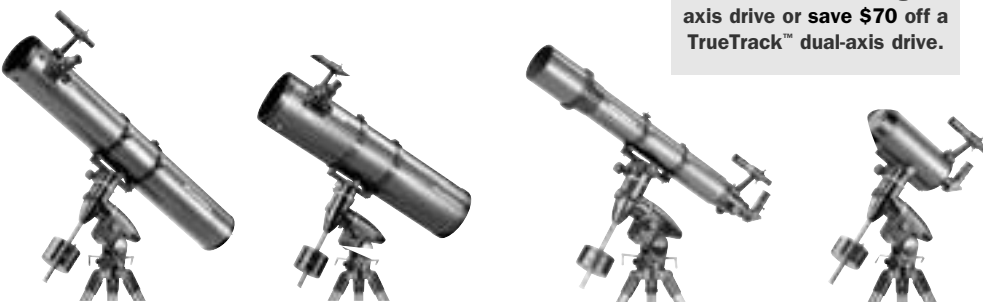
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news 06

Read all about it: catastrophic landslides on Mars, two bipolar dust jets near the solar system, X rays from Saturn, and gamma-rays from the Milky Way.

HUBBLE HERITAGE IMAGE

Swirling echoes of light

Astronomers are still debating the nature of a January 2002 outburst from a faint star in the constellation Monoceros. The star, designated V838 Mon, suddenly brightened to 600,000 times the luminosity of our Sun and briefly became one of the brightest stars in our galaxy. It faded in April 2002. Despite two years of monitoring the star and its environment, astronomers remain unsure why the outburst occurred at all.

"There's not a whole lot that astronomers agree on

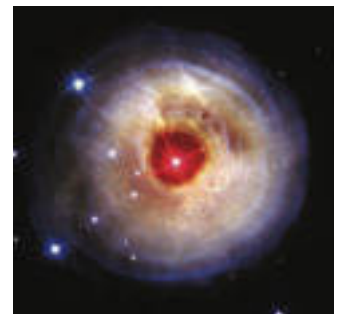
about V838 Mon," says Howard Bond of the Space Telescope Science Institute in Baltimore, Maryland. One group explains the eruption as the merger of two unequally matched main sequence stars in which a more massive star expanded as it cannibalized its low-mass companion. Another group proposes the flare-up occurred as the red supergiant star expanded and swallowed nearby giant planets. Others, like Bond, argue the outburst came from a thermonuclear explosion ejecting the star's outer layers, the same process powering classical novae.

As the pulse of light from the outburst spread from the star, it illuminated delicate shells of dust. Most astronomers believe the dust is material previously ejected by the star. Bond has been using the Hubble Space Telescope to monitor the "light echo" of the outburst as it expands, revealing complex patterns in V838 Mon's dusty shell. Geometric measurements of the light echo suggest V838 Mon lies some 20,000 light-years away from Earth. — FRANCIS REDDY



A BLAST WAVE OF LIGHT from an outburst by the irregular variable star V838 Monocerotis is expanding into the swirling clouds of dust and debris cast off by the star in earlier eruptions. The image above was taken by the Hubble Space Telescope on February 8, 2004. The image at right, shown to the same scale, dates from May 20, 2002.

NASA/ESA/S. BECKWITH (STScI)



24 Probes heading to the Moon this summer?

25 Ice near Mars's equator

26 Hubble's ultra-deep stare into early time

28 Pearly knots in super-nova 1987A's blast wave



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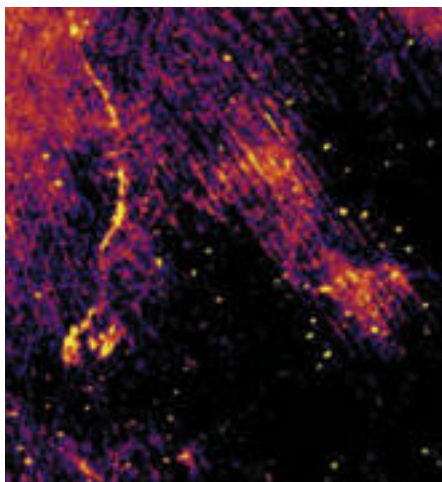
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STELLAR ASTRONOMY

Two dust jets near the solar system

Two large jets of dust, the first to be discovered at infrared wavelengths, lie in interstellar space about 200 light-years from the solar system, according to two astronomers at the University of Innsbruck, Austria. Using decades-old data



PART OF A PAIR of dust-jet “worms” stretches across about 9° of sky in Boötes. The jets’ exact origin and nature are not known. NASA/R. WEINBERGER

from the Infrared Astronomy Satellite (IRAS), Ronald Weinberger and Birgit Armsdorfer identified two faint stars with bipolar dust jets. The stars lie close to each other in the sky near R.A. 14h23.7m, Dec. +40°. Each jet is about 9° long.

The jets are very red and glow faintly at temperatures of 25 to 30 kelvins. Both jets have “bubbles” about a degree in diameter at each end that appear to be shock waves.

The astronomers report that the jets’ similarity and closeness to each other in space hint they are related. Weinberger and Armsdorfer suggest these are fossils left when a massive star shed material into the accretion disks of two smaller stars.

These results will appear in a forthcoming issue of *Astronomy & Astrophysics* and are on the preprint server at arxiv.org/abs/astro-ph/0402307. — ROBERT BURNHAM

“Maybe” to the Moon this year

As NASA draws up plans for new robot Moon probes in the 2008–2009 period, the Moon won’t be lonely. Aside from Europe’s SMART-1 probe inching toward an early 2005 arrival, two other unusual lunar missions are planned for launch later this year. Because their sponsors are inexperienced, a measure of suspense hovers around when — or even if — the missions will launch, and whether they will work.

Japan has planned an ambitious mission called Lunar-A, and after years of delays and redesigns, it appears ready to fly later this summer. Its novel feature is the first attempt in forty years to hard-land probes on the Moon’s surface. A pair of 29-lb (13-kg) “penetrometers” will detach from the mother ship, fire a rocket to kill their orbital speed, and then drop straight down from an altitude of about 15 miles (25 km).

Each arrow-shaped impactor will hit the regolith at about 1,000 feet (300 meters) per second, burrowing several yards down. Assuming the impactor survives, a seismometer will sense moonquakes while a heat-flow probe will detect temperatures. For up to a year, data will be transmitted in bursts to the orbiter, which will be mapping the surface



HARD-LANDING IMPACTORS equipped with seismometers will be launched from Japan’s Lunar-A probe this summer. The mission’s main goal is to measure moonquakes. JAXA ARTWORK

along the Moon’s day-night terminator.

The second possible lunar mission this year is Trailblazer, a privately-funded probe hitchhiking on a surplus Russian military rocket. Organized by a company called Transorbital, with additional corporate sponsorship from Hewlett-Packard, the project has already sent a test payload into low-Earth orbit on a Russian missile test. This booster, called Dnepr, is a decommissioned Soviet-era intercontinental attack missile designed for launch from an underground silo in a far corner of Russia’s Baykonur Cosmodrome in Kazakhstan.

The probe may be launched this fall, and it will orbit the Moon for at least 90 days taking pictures. It then will be steered into an impact on the surface.

The crash is actually part of the funding plan. Subscribers are sending business cards, certificates, photographs, jewelry, artwork, etched messages, and even cremated human remains — all packed aboard the small probe for a fee of \$2,500 per gram.

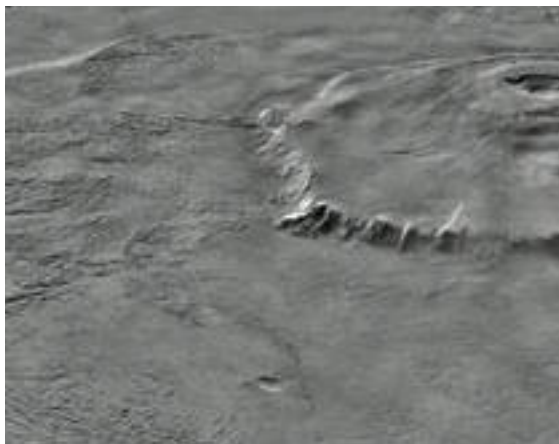
“Advertising customers are a little harder to come by,” project leader Dennis Laurie told *Astronomy*. “But the President’s new initiative has been very helpful.”

— JAMES OBERG



PLANETARY SCIENCE

Catastrophic landslides at Olympus Mons



A JUMBLED TERRAIN OF BLOCKS and ridges flanks the giant volcano Olympus Mons. The blocks are debris that slid away from the volcano, helped by groundwater at its base. NASA/JPL

High-resolution images from the Mars Global Surveyor have ended an old debate on the origin of the jumbled terrain around Olympus Mons, according to Patrick McGovern (Lunar and Planetary Institute) and a team of planetary scientists.

Flanking the martian volcano to the west, north, and east sides lie the “aureole deposits,” giant ridges and blocks extending some 600 miles (1,000 km). Theories for the deposits’ origin include ash flows, glacial deposits, and thrust-faulted sheets of lava. The most popular theory, however, has been landslides, thanks in part to the 6-mile-high (10 km) scarp at the volcano’s base, which is a possible scar.

“Reassembling the volcano from the estimated volume of the deposits doesn’t greatly enlarge the volcanic edifice,” says McGovern, answering one criticism of the landslide theory. His group used high-resolution photos from the MOC imager aboard Mars Global Surveyor to study the deposits in detail.

“Blocks in the aureole deposits look like pieces of the volcano,” he says. The blocks also resemble huge underwater landslides that fell off the Hawaiian islands in prehistoric times.

Olympus Mons’ slopes are too shallow (about 6°) to set off a landslide by themselves, McGovern notes, so the researchers looked to subterranean water.

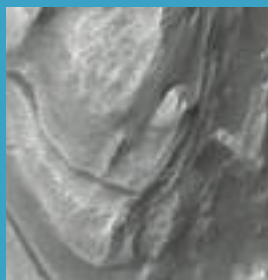
“The Hawaiian slope failures slipped on water-saturated sediments — it’s reasonable for a similar process to work on Mars,” he says. — R. B.

PLANETARY SCIENCE

Surface ice near the martian equator?

Scientists studying images of a near-equatorial area on Mars named Juventae Chasma think they see light-colored deposits that could be water ice mixed with dust and sand. If true, it’s the first identified exposure of water ice at low latitudes, where most scientists thought ice could not exist currently.

The suspect deposits have a color, a brightness, and thermal properties that match proven exposures of water ice in the polar regions. — R. B.



EXPOSED WATER ICE may lie within layers of dust and sand in an equatorial canyon on Mars. NASA/JPL/MSS

PLANETARY SCIENCE

Digitizing Lunar Orbiter photos

Five unmanned Lunar Orbiter missions reconnoitered the Moon in preparation for the Apollo landings. But their superbly detailed photos belong to the predigital era.

The U.S. Geological Survey has a project directed by Tammy Becker (USGS Flagstaff) to digitize frames from these missions and make them available on the Internet to everyone, Moon buffs and planetary scientists alike. See astrogeology.usgs.gov/Projects/LunarOrbiterDigitization/.

“Our initial focus is on Lunar Orbiters IV and V, which gave global coverage,” says Becker. “Plus we’re doing Lunar Orbiter III. Its very high resolution imagery was aimed at possible Apollo landing sites.” — R. B.



THIS COPERNICUS image mates a 1960s Lunar Orbiter image to 1990s mineral data from Clementine. USGS

PLANETARY SCIENCE

Sedna poses solar system puzzle

Astronomers at Caltech, the Gemini Observatory, and Yale University have discovered the most distant solar system object to date. They have provisionally named it Sedna, after the Inuit sea

goddess. Sedna never approaches the Sun closer than about 75 times the Earth-Sun distance, and each orbit takes more than 12,000 years. Likely a mixture of ice and rock, Sedna spans roughly 900 miles (1,400 kilometers), about three-fourths Pluto’s size.

“There is absolutely nothing else like it known in the solar system,” says Mike Brown (Caltech), discovery team leader.

Sedna poses a big puzzle because astronomers say that its present orbit has to be the result of perturbations by another massive body’s gravity. But that object’s identity, and its whereabouts today, remain unknown. — R. B.



NEARLY AS RED AS MARS, Sedna is the most distant object yet found in the solar system. ARTWORK: M. BROWN/CALTECH

COSMOLOGY

Hubble goes *very* deep

DISTANT GALAXIES appear in this portion of the Hubble Ultra Deep Field photograph. The image was part of a multiple exposure taken between September 2003 and January 2004. STScI

The Hubble Space Telescope (HST) has taken the deepest image of the distant cosmos ever made. The Hubble Ultra Deep Field was a million-second (nearly 12-day) exposure of a field in the constellation Fornax only one-tenth the size of the Full Moon. HST picked up galaxies at the edge of detection, as they were just 300 million years after the Big Bang.

Last month, *Astronomy* reported the discovery of a galaxy at a redshift of about 7, or 750 million years after the Big Bang. (Redshift results from the universe's expansion and thus serves as an indicator of distance.) Just two weeks after that discovery was made public, another galaxy was announced with a redshift of 10, putting it 460 million years after the Big Bang. The newly discovered galaxies in the Hubble Ultra Deep Field have redshifts ranging from 7 to 12.

Astronomers are eager to push back this frontier because they want to know how the first stars and galaxies formed out of the clouds of gas that emerged from the Big Bang. The galaxies detected by Hubble come from an era immediately after what astronomers call the Dark Ages, a period before the universe became transparent to radiation.

HST's Ultra Deep Field goes deeper than any groundbased telescope can. Thus the image will not be bested until HST's replacement, the James Webb Space Telescope, is launched, in 2011 or later. — R. B.

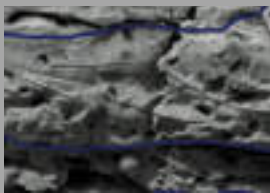
PLANETARY SCIENCE

Opportunity rover hits the beach

The Mars rover Opportunity landed on what was "once the shoreline of a salty sea," says mission scientist Steve Squyres (Cornell University).

Ripple marks only a few inches (centimeters) in size show as crossbedding in the sulfate-rich outcrop, as seen by Opportunity's microscopic imager. The layers were deposited in shallow water flowing a few inches (cm) per second, according to mission scientists.

Says Ed Weiler, NASA associate administrator for space science, "If you want to find fossils, this is where you'd start." — R. B.



RIPPLE MARKS make telltale "smiles" in the outcrop rock as seen by Opportunity's microscopic imager. NASA/JPL/CORNELL

PLANETARY SCIENCE

X rays detected from Saturn

Astronomers using the Chandra X-ray Observatory have made the first clear detection of X rays from Saturn. The team was led by Jan-Uwe Ness (Univ. of Hamburg, Germany).

Writing in a forthcoming issue of *Astronomy & Astrophysics*, the scientists note that Saturn's X-ray spectrum generally resembles the Sun's, indicating the planet's atmosphere is reflecting solar X rays.

However, the team was surprised to find Saturn's X rays coming from

its equatorial region, not its polar aurorae (as at Jupiter). However, the reflection's 90 megawatt strength roughly parallels Jupiter's.

"The intensity of the X rays means that Saturn reflects more than 50 times better than the Moon," says Ness. — R. B.



X RAYS REFLECTING from Saturn's equatorial region have a solar spectrum. CXC

HIGH-ENERGY ASTROPHYSICS

Gamma-ray glow's sources found

The origin of a diffuse glow of soft (or low-energy) gamma-rays that has puzzled astronomers for thirty years has been found in almost a hundred individual gamma-ray sources within the Milky Way.



ALMOST A HUNDRED gamma-ray sources lie in the Milky Way, making a glow resolved for the first time. ESA/F. LEBRUN

A team of astronomers led by François Lebrun (CEA-Saclay, France) used the European Space Agency's INTEGRAL gamma-ray observatory to map the Milky Way's central region for the first time at high resolution.

They found 91 individual sources. These objects are likely to include neutron stars, pulsars, and black holes that are accreting dust and gas from their surroundings. The team's next step will be to study each source to identify the mechanism powering it.

Says Lebrun, "It's tempting to extrapolate to the entire galaxy. But we looked only toward its center and that's a peculiar place." — R. B.

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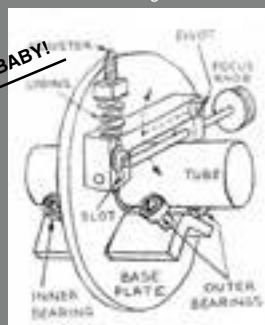


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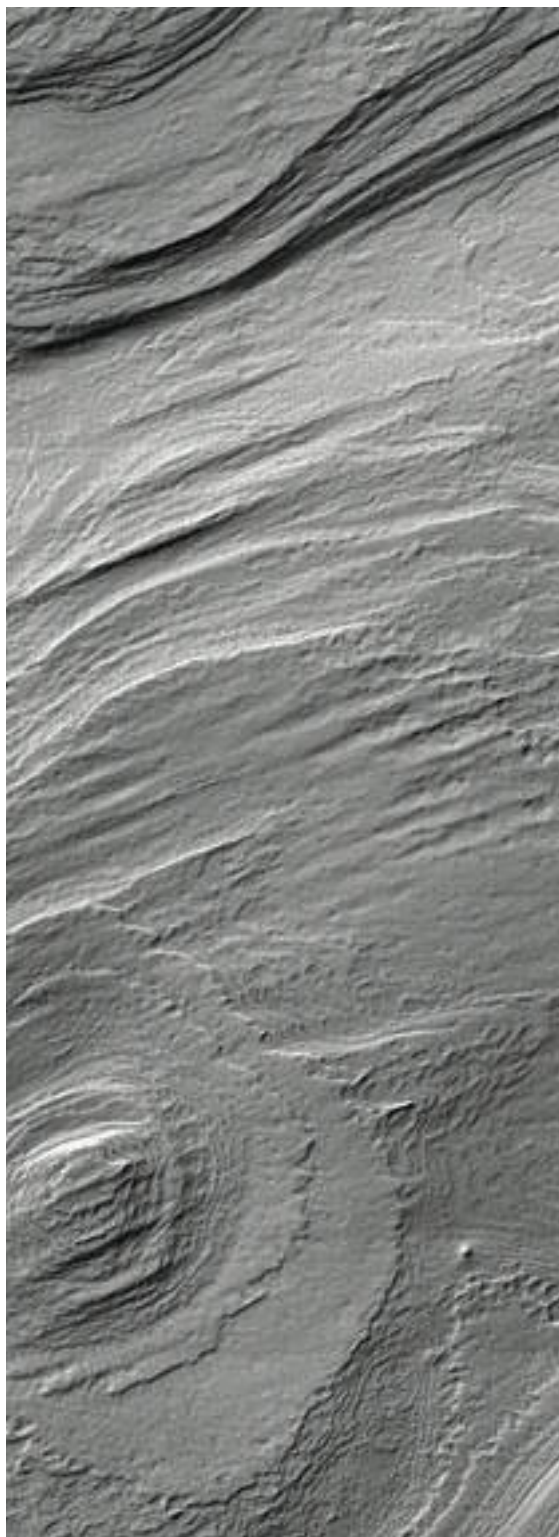
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South polar cap layers

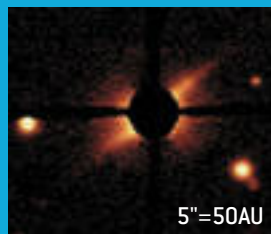


RECORDS OF ANCIENT ICE-AGE CYCLES lie in the martian polar deposits, such as these belonging to the south polar cap, seen in March 2002 during southern summer. NASA/JPL/ASU IMAGE 20040308A

EXOPLANETS

Dust disks common?

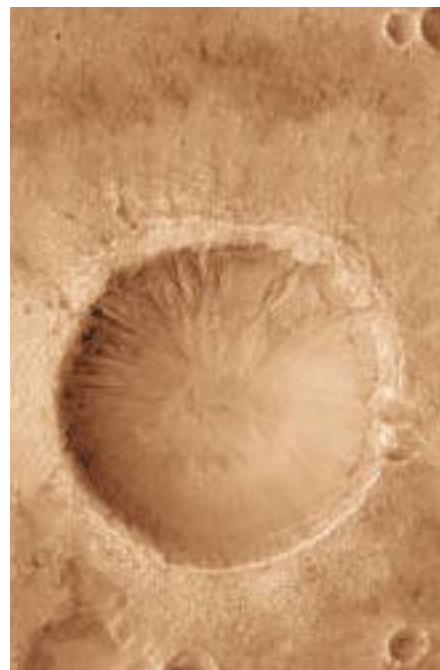
The young, nearby star AU Microscopium has a dust disk around it like that seen at another young star, Beta (β) Pictoris. Both stars are type M, which makes up 85 percent of all stars.



DUST DISKS around common stars imply planetary systems may be numerous. UC BERKELEY

The finding suggests that such disks, and the planets that form within them, are common. A team led by Paul Kalas (UC-Berkeley) mapped AU Mic's disk from 50 to 210 AU from the star. Writing in *Science Express* (February 26, 2004), they add that because dust is spiraling into the star, collisions between disk particles must be replenishing the dust. — R. B.

MARS PHOTOJOURNAL



GULLIES FURROW THE WALLS of a crater in Terra Cimmeria, while wind-blown deposits collect on its floor. Scientists think such gullies are eroded by water emerging from bedrock or melting ice or snow in the recent past. The image, sunlit from the upper left, spans about 1.9 miles (3 kilometers). NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE R11-03236

STELLAR ASTROPHYSICS

Supernova 1987A's pearly ring

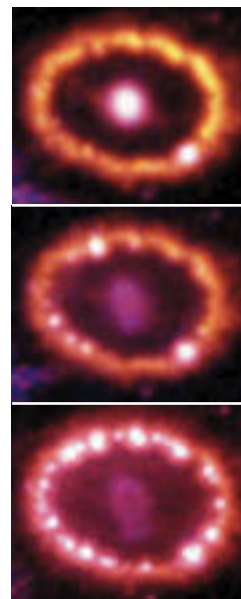
The explosion of supernova 1987A fired a blast wave into space that now has reached about 1 light-year in diameter. It is slamming into debris cast off by the progenitor star about 20,000 years ago, heating it hot enough to emit X rays.

Astronomers noticed the first million-degree hotspot in 1996. Over the years, images taken by the Hubble Space Telescope's Advanced

Camera for Surveys (ACS) has tracked an increasing number of X-ray-bright knots. (From top to bottom, the ACS images show the ring on September 24, 1994; June 16, 2000; and November 28, 2003.)

Eventually, the shock wave will tear the ring apart. — R. B.

OVER NINE YEARS, the expanding shock wave from supernova 1987A has made a full ring of bright hotspots that look like pearls. NASA/STScI



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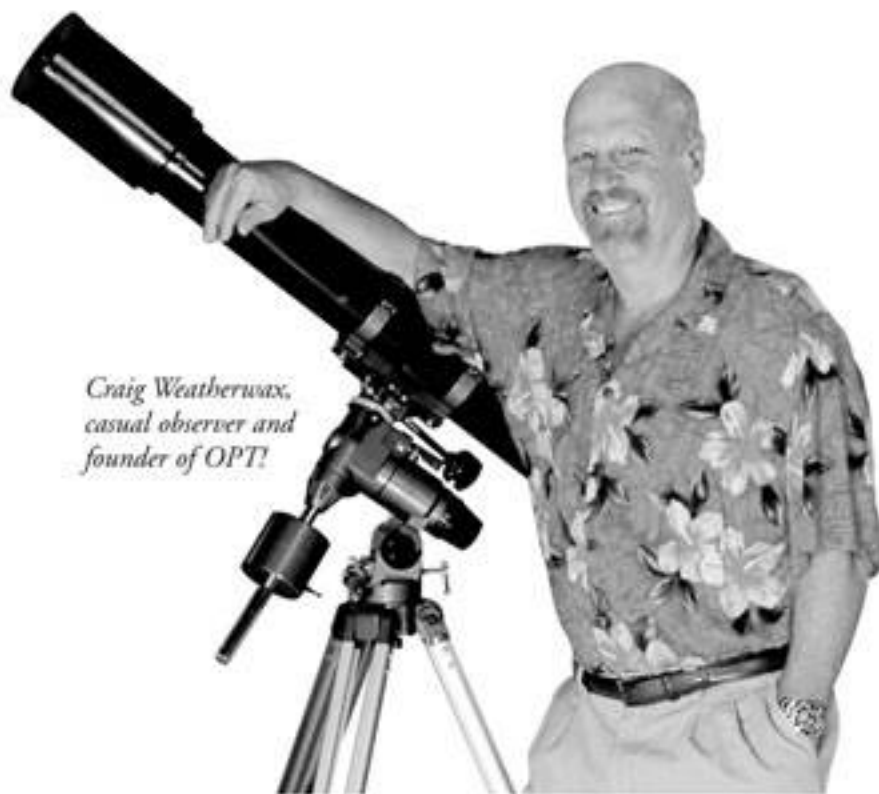


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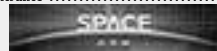
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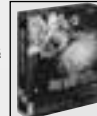
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The first discovered trail of the planet Mars, showing the path of the planet as it moves across the sky, and the position of the planet at the time of its discovery. The trail is shown in a series of small circles, each representing a position of the planet at a different time. The circles are arranged in a series of small circles, each representing a position of the planet at a different time. The circles are arranged in a series of small circles, each representing a position of the planet at a different time.

Transit of Venus

Among the rarest of celestial events, transits of Venus have enticed generations of astronomers seeking the size of the solar system. /// BY RAY JAYAWARDHANA

There will be no other till the twenty-first century of our era has dawned upon the earth, and the June flowers are blooming in 2004,” mused William Harkness of the U.S. Naval Observatory back in 1882. He was referring to a transit of the planet Venus across the Sun’s visage, which he and scores of other astronomers of the time were preparing to observe. “When the last transit season occurred the intellectual world was awakening from the slumber of ages, and that wondrous scientific activity which has led to our present advanced knowledge was just beginning. What will be the state of science when the next transit season arrives, god only knows,” he added, giving some historical context to these rare events.

That distant future Harkness spoke of has arrived. On June 8, we will witness the first Venus transit in more than a century. These celestial



ENGLISHMAN JEREMIAH HORROCKS (left) was one of the first two people to view a Venus transit. Here he examines the black dot of Venus on the Sun’s disk, which is being projected by a small telescope. The plaque below reads, “The first observed transit of the planet Venus predicted and observed by the Rev. Jeremiah Horrox [sic] on 24th Nov. 1639. ‘I immediately lost all doubt that this was the shadow of Venus and applied myself to the careful observation of it.’ ” 1903 PAINTING BY J. W. LAVENDER, COURTESY ASTLEY HALL MUSEUM & ART GALLERY
KEPLER PREDICTED “the rare and wonderful phenomena of 1631” in a 1629 paper (right). Although no one saw the 1631 Venus transit, observations of that year’s Mercury transit whetted astronomers’ appetites for the 1639 transit of Venus.



LIEUTENANT JAMES COOK'S EXPEDITION observed the 1769 transit of Venus from the French Polynesian island of Tahiti. Cook's observations, combined with others from around the world, helped refine our knowledge of the distance to the Sun. Expedition members also studied the flora and fauna they encountered and even "discovered" Australia, one of the first spin-offs from astronomical research. LINDA HALL LIBRARY OF SCIENCE, ENGINEERING & TECHNOLOGY

alignments follow a precise cycle, with time intervals of 8, 121.5, 8, and 105.5 years. If the orbits of Venus and Earth were in the same plane, we would see a transit every 19 months — each time Venus passes between the Sun and Earth at inferior conjunction. But the two orbits are inclined 3.4° with respect to each other. Venus intersects the plane of Earth's orbit twice every year, in early June and early December, at points called nodes. Transits occur so rarely because Venus must be passing through a node during inferior conjunction, placing Venus exactly between the Sun and Earth.

As Venus crosses in front of the Sun, typically taking several hours to do so, it appears as a black dot about $\frac{1}{30}$ the solar diameter. Although big enough to see with the properly protected naked eye, no records exist of a transit being observed before the invention of the telescope early in the 17th century. That's not too surprising given the rarity of the event.

In 1629, when Johannes Kepler was investigating the laws of planetary motion, he realized that transits of both Venus and Mercury would occur two years later. Unfortunately, he didn't live to see either, and the 1631 Venus transit couldn't be seen from Europe in any case. Yet European astronomers did observe the Mercury transit in November that year, vindicating Kepler's prediction. Eight

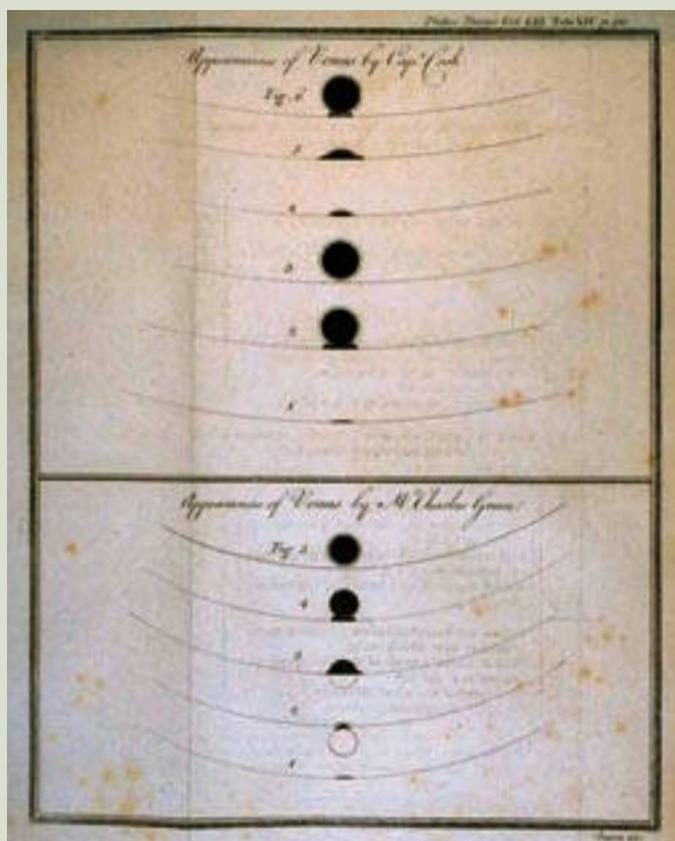
years later, Englishmen Jeremiah Horrocks and William Crabtree, friends living 30 miles apart, made the first recorded observations of a Venus transit by projecting the Sun's image with small telescopes onto paper.

Perhaps inspired by a Mercury transit he observed from the island of St. Helena in 1677, Edmond Halley, of comet fame, presented a paper to the Royal Society in London in 1691 on how to use transit timings to measure the distance between the Sun and Earth. At the time, this distance — known as the astronomical unit, or AU — was not known to much better than a factor of two. Although Kepler's study of planetary motion had fixed the *relative* distances between the known planets, the *absolute* distances remained a fundamental question.

Halley's suggestion, an idea also proposed by a Scottish mathematician almost thirty years earlier, was to time the transit accurately from widely separated locations on Earth. The difference in the apparent paths taken by Venus across the Sun's face then could be used to calculate the Earth-Venus distance and thus, the Earth-Sun distance using trigonometry. An accurate measurement of the AU not only would set the distance scale for the solar system, but it also held the more down-to-earth promise of improving celestial tables needed for maritime navigation.

After Halley's death, others took on his charge of organizing expeditions to observe the 1761 and 1769 Venus transits from various parts of the globe. Despite the challenges of long-distance sea travel by wooden sailing ship, the difficulty of obtaining and using precise clocks and other instruments, and the dangers posed by the ongoing Seven Years' War between England and

Ray Jayawardhana is an assistant professor of astronomy at the University of Michigan. He explores the origins of planets, brown dwarfs, and stars. His article "Beyond black" in the June 2002 issue of *Astronomy* won a science writing award from the American Institute of Physics.



THE BLACK-DROP EFFECT, seen here in Cook's sketches, prevented observers from precisely timing the event and limited the usefulness of transit observations made by even the best visual observers. ROYAL SOCIETY

France, astronomers from those two countries and Austria mounted expeditions for the first transit to such far-flung venues as Newfoundland, St. Helena, Norway, Siberia, and the Indian Ocean. Even with some 120 observers in total, it turned out that the spread in latitude was far from optimal for determining the AU. With the added uncertainties of timing, bad weather in some locations, and not knowing the exact longitude of others (such as Rodrigues Island just east of Mauritius), the much-hoped-for improvement in measuring the AU did not materialize.

The apparent failures of 1761 made it all the more important to get things right for the next transit eight years later. A commission set up by the Royal Society called on King George III to support an expedition to Tahiti to observe the 1769 transit. The proposal highlighted the practical value of the result, stating that a transit measurement would “contribute greatly to the improvement of astronomy on which Navigation so much depends.” It even appealed to national pride: “The French, Spaniards, Danes and Swedes are making the proper dispositions for the Observation thereof.... The Empress of Russia has given directions for having the same observed.... It would cast dishonor [on the British people] should they neglect to have the correct observations made of this important phenomenon.” These arguments, and the cost underestimate of 4,000 pounds “exclusive of the expense of the ship,” sound remarkably familiar to today’s scientists asking for government funds for space missions.

The king found the arguments persuasive and approved the funds. The small Royal Navy ship *Endeavor* set off in August 1768 with Lieutenant James Cook in command. It also carried English

/// Venus transits, once and future

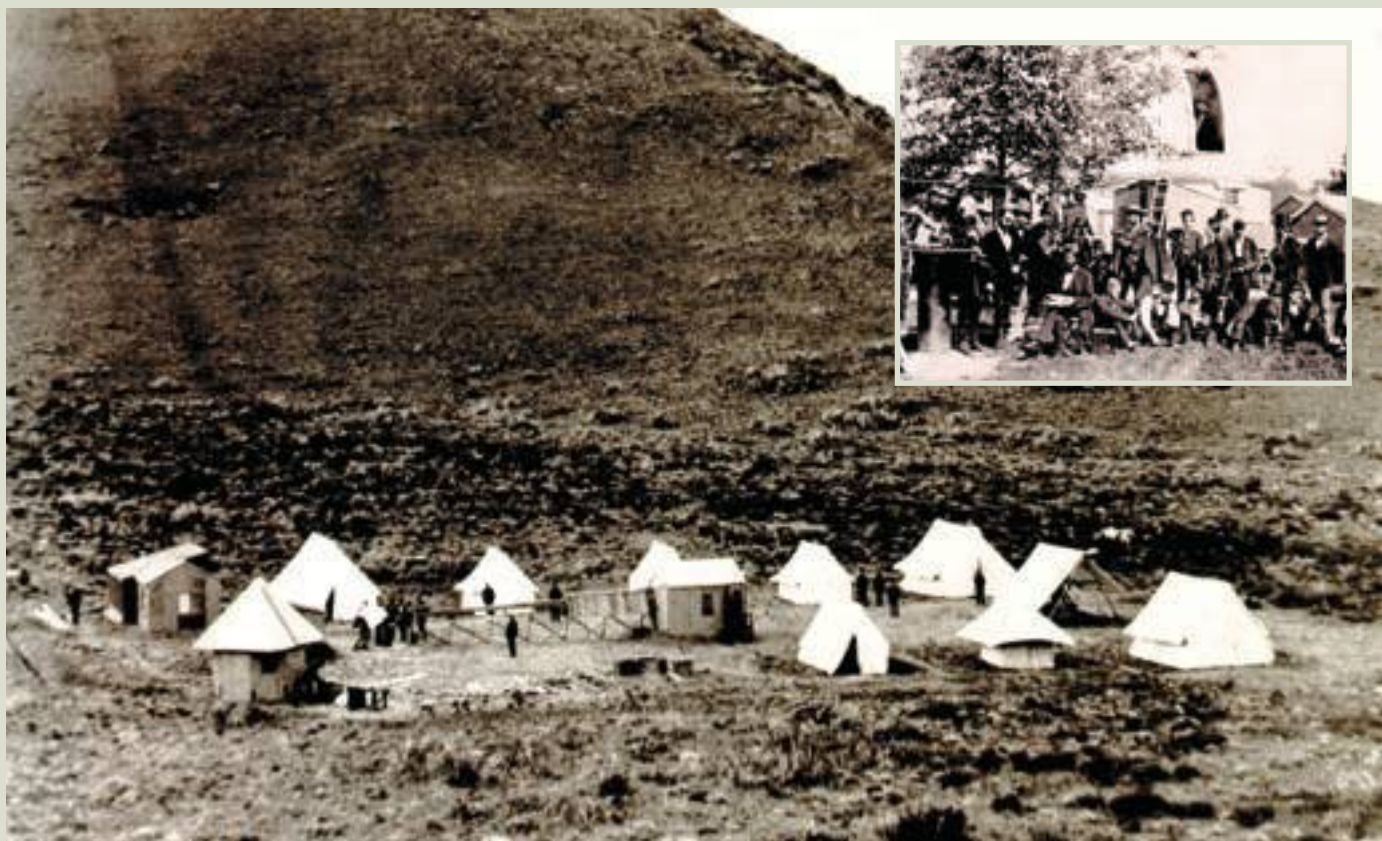
DATE	TIME	DURATION
May 26, 1518	1h56m	6h56m
May 23, 1526	19h11m	5h55m
Dec. 7, 1631	5h19m	2h56m
Dec. 4, 1639	18h25m	6h57m
June 6, 1761	5h19m	6h35m
June 3, 1769	22h25m	6h20m
Dec. 9, 1874	4h07m	4h37m
Dec. 6, 1882	17h06m	6h18m
June 8, 2004	8h20m	6h13m
June 6, 2012	1h29m	6h40m
Dec. 11, 2117	2h48m	5h40m
Dec. 8, 2125	16h01m	5h33m
June 11, 2247	11h33m	5h43m
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Dec. 13, 2360	1h44m	6h24m
Dec. 10, 2368	14h45m	4h32m
June 12, 2490	14h17m	5h16m
June 10, 2498	7h25m	7h14m

TRANSITS OF VENUS occur at intervals of 8, 121.5, 8, and 105.5 years. “Time” refers to the Universal Time of greatest transit, while “duration” indicates the length of each transit for a hypothetical observer at Earth’s center.

astronomer Charles Green, Swedish naturalist Daniel Solander, and a gentleman traveler named Joseph Banks, who contributed 10,000 pounds of his own money, as well as scientific instruments, crew, and supplies. They arrived in Tahiti six weeks before the transit and set up an observing post at a location later christened Point Venus. The day of the transit “prov’d as favorable to our purpose as we could wish, not a Cloud [*sic*] was to be seen all day and the Air was perfectly clear,” Cook wrote in his journal. But timing the end of ingress and the start of egress, when Venus lies just inside the limb of the Sun, proved difficult. Cook’s party noted that at these contact points, the planet’s dark disk appeared distorted in the shape of a raindrop, as if a thread were connecting it to the Sun’s limb. This so-called black-drop effect limited the precision of the transit timings.

Following the transit, Cook explored New Zealand and the east coast of Australia in an attempt to fulfill the second (and secret) part of his mission: to search for a mysterious southern continent. The *Endeavor* returned to England after three years at sea. The transit data it brought back, when combined with those from other sites around the world, allowed astronomers to determine the AU to within a few percent of its modern value — a remarkable achievement.

But the measure of the AU derived from various methods at the time did not agree very well: reported values ranged from about 91 million to 97 million miles. Thus, on the eve of the next pair of Venus transits in 1874 and 1882, the distance to the Sun



NAVAL OBSERVATORY ASTRONOMERS sent eight identically equipped expeditions to points around the globe to observe the 1874 transit of Venus. This photo shows the camp at Kerguelen Island in the southern Indian Ocean. Each setup included an instrument known as a photoheliograph that would cast the Sun's image onto a glass photographic plate located 38.5 feet away. U.S. NAVAL OBSERVATORY Inset, **THE EIGHT TEAMS** gathered on the grounds of the Naval Observatory in Washington, D.C., in the spring of 1874 to practice for the big event coming late that year. U.S. NAVAL OBSERVATORY

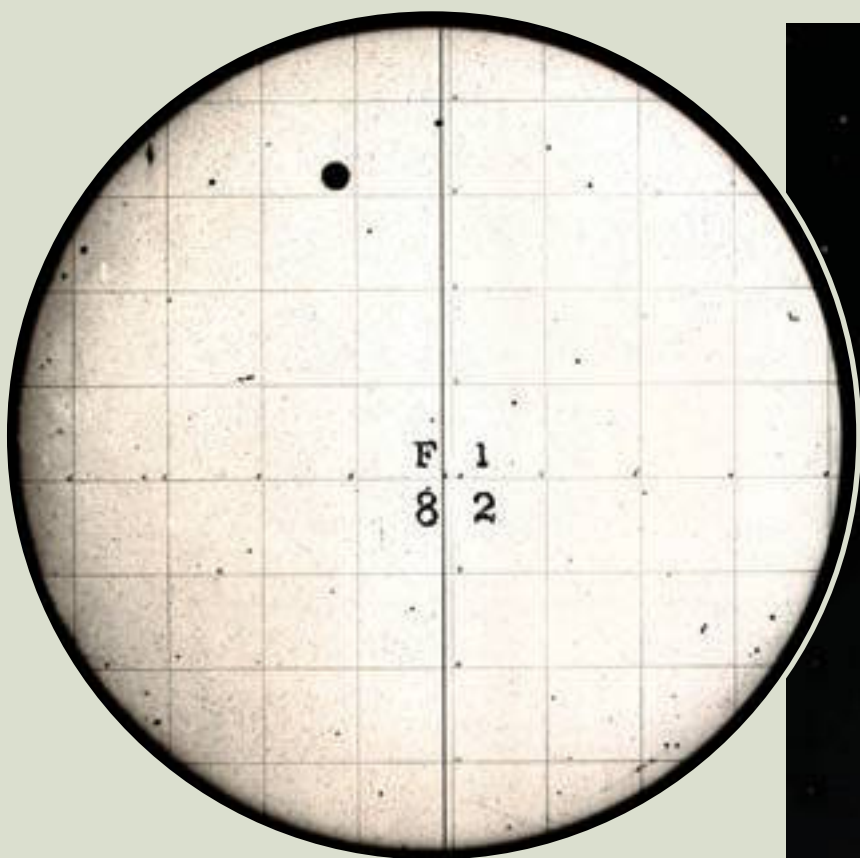
— what British Astronomer Royal George Airy called “the noblest problem in astronomy” — remained somewhat uncertain. Its resolution was deemed sufficiently important that to observe the 1874 event, Britain, France, Germany, Holland, Italy, Russia, and the United States launched a total of more than sixty expeditions.

In the United States, it was Simon Newcomb at the Naval Observatory who took the initiative to create a Transit of Venus Commission, even though he was personally “not at all sanguine” about the prospect of measuring the Sun’s distance this way. At the commission’s urging, Congress appropriated the remarkable sum of \$177,000 to equip and support eight expeditions. Since photography was still in its infancy, American astronomers, like their European counterparts, hedged their bets by making both photographic and visual observations. Given the limitations posed by the black-drop phenomenon, in addition to timing the points of contact at the beginning and end of the transit, they attempted to measure the position of Venus on the Sun’s disk directly. Unfortunately, several observing parties, including one to Tasmania led by Newcomb’s colleague William Harkness and another to Siberia headed by Asaph Hall — who discovered the moons of Mars — encountered cloudy weather. What’s more, even observations from clear sites did not improve the precision from a century before, despite laborious analysis of the data by Harkness and others.

After these failures, Newcomb lost faith in the value of transits for measuring the Sun-Earth distance. But Harkness remained

hopeful; he and others persuaded Congress to appropriate another \$85,000 to improve equipment and send expeditions for the 1882 Venus transit. This transit could be seen from many parts of the United States, so Harkness observed from Washington, D.C., and Hall from San Antonio, Texas. Newcomb — despite his serious doubts — led a team to the Cape of Good Hope in South Africa. The observers had better luck with the weather this time, resulting in more and better data. Harkness was determined to derive a final result from this wealth of observations: In 1888, after six years of painstaking analysis, he reported a value of 92,385,000 miles, with a probable error of 125,000 miles, for the distance to the Sun. He continued working on the data for several more years, and gave 92,797,000 miles, with a probable error of 59,700 miles, as the best estimate in his presidential address to the American Association for the Advancement of Science in 1894. However, Newcomb, whose system of astronomical constants proved to be the standard for much of the 20th century, assigned a rather low weight to Harkness’s result for the Sun-Earth distance when compared with values derived from other methods.

As already mentioned, the black-drop effect remained a key problem plaguing transit-timing observations. Its physical cause has been the subject of much confusion and controversy over the years. Various explanations have been invoked, among them light diffraction around the planet’s disk, refraction through Venus’s atmosphere, and an optical illusion. But according to astronomer Bradley Schaefer of Louisiana State University, the explanation that best fits the facts is one that was proposed by J. J. Lalande and



VENUS APPEARS AS A BLACK DOT near the top of the Sun in this U.S. Naval Observatory image. Of the more than 10,000 photographic plates acquired during the Observatory's expeditions in 1874 and 1882, this is one of only 11 that survive. U.S. NAVAL OBSERVATORY



THE KEPLER SPACECRAFT will monitor some 100,000 stars for more than four years, trying to detect Earth-size planets in orbit around other stars. To find the small brightness variations caused by planets like ours, the telescope must be in space. NASA plans to launch Kepler sometime in 2007. NASA

Charles Messier in 1769: The phenomenon results mainly from Earth's atmosphere blurring the image. A few years ago, Schaefer modeled the atmospheric smearing and showed that it indeed produces an effect like that seen in the black drop.

Further evidence that the black-drop effect has little to do with the transiting planet's own atmosphere comes from observations of the 1999 Mercury transit by the Transition Region And Coronal Explorer (TRACE) spacecraft. When observed from space, airless Mercury showed a small black-drop effect. Analysis of TRACE data by Glenn Schneider of the University of Arizona, Jay Pasachoff of Williams College, and Leon Golub of the Smithsonian Astrophysical Observatory (SAO) suggests the effect was caused by a combination of solar limb darkening and how the TRACE instrument records incoming light. When TRACE observes the Venus transit this summer, the same explanation should be able to account for its black drop.

Beyond testing the proposed cause of the black-drop phenomenon, the value of the 2004 transit of Venus is mostly educational rather than scientific. Venus's distance now can be measured using radar, and the AU is known to within 30 meters.

But transits of another kind — those of planets orbiting other stars — are at the forefront of our quest to identify and explore worlds beyond the solar system. Of some 120 extrasolar planets discovered so far, two have been detected in transit, as small, periodic dips in their parent star's light when the planet passes in front and blocks about one percent of the star's light. The depth of the dip reveals the diameter of the planet. Transit observations

prove most useful when they're combined with radial velocity measurements of the star as it wobbles from the planet's gravitational tug. Together, this information enables astronomers to infer the planet's mass and density. The two transiting extrasolar planets currently known — HD 209458b and TR-56b — are both gas giants, akin to Jupiter. Currently, two dozen planet-transit searches are underway around the world, including at least one that involves amateur observers (see www.transitsearch.org).

Astronomers now are getting ready to search for earthlike planets using the transit method. Because the dips in brightness caused by such small planets passing in front of their suns is extremely tiny, the detection of decreases in brightness requires observations from space. That is the goal of Kepler, a NASA mission scheduled for launch in 2007. Kepler's photometric measurements will be 100 times more precise than those made from the ground, making it possible to look for planets 100 times smaller than Jupiter. It will monitor 100,000 stars for at least four years in search of subtle, periodic drops in brightness, the telltale signal of earthlike planets in transit.

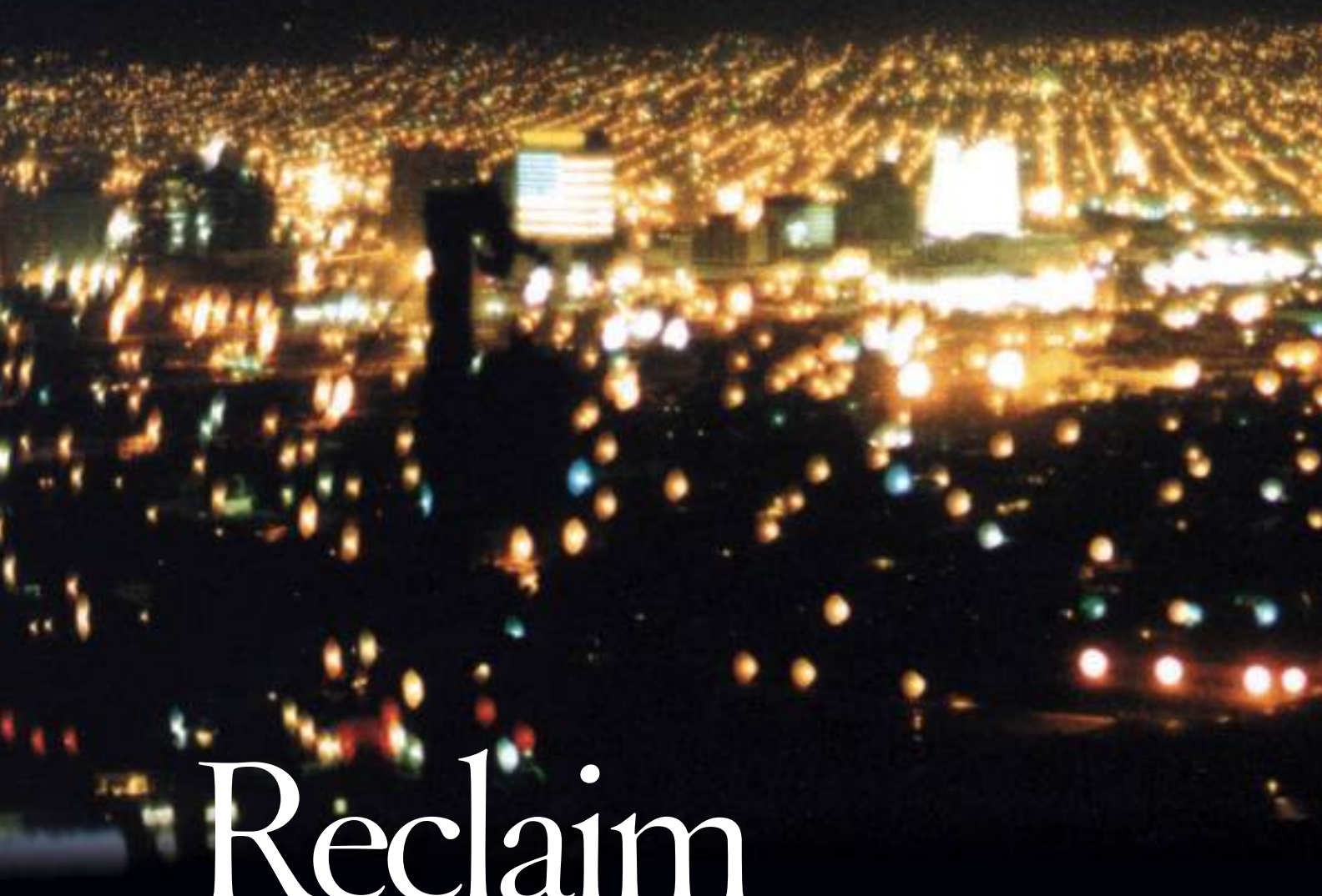
William Harkness surely would be amazed by scientists on the verge of looking for transits of extrasolar Earths as the "June flowers are blooming in 2004." By the time Earth's local twin, Venus, next transits the Sun in 2012, we may have discovered distant cousins around other suns. ■



To learn more about transits of Venus throughout history, visit www.astronomy.com/toc

{ AMATEUR ASTRONOMY }

Fighting light pollution is not a hopeless task, but it requires
backyard astronomers to get active politically /// BY MICHAEL E. BAKICH



Reclaim • the night sky



EVERYONE WHO LOVES OBSERVING THE NIGHT SKY, OR TAKES PHOTOS OF IT, soon becomes aware of a Big Problem. Excess nighttime lighting, generally called light pollution, has increased much during the last several decades and continues to grow at a high rate. In today's world, the most immediately endangered natural resource is the dark night sky.

For much of the population of North America and Europe, the night sky is no longer black, or even dark. Instead, almost bereft of stars, it glows yellow-orange, lit by poorly designed fixtures and spillover light from human activities. Satellite images of Earth no longer show the night side of our planet as dark. For some people born in the 1980s or later, it's possible the only celestial object they've ever seen in the night sky is the Moon.

Few, if any of us, favor the utter abolition of outdoor lighting. It is necessary for safety and security during work or recreational activities. Other lighting, such as that which spotlights historical buildings, parks, shopping areas, or advertising, may not be entirely necessary, but it is desirable to many. These lighting situations would be tractable if they didn't come embedded in more problematic ones.

For example, everyone has encountered lighting that seems to serve no purpose, is poorly designed, or is in need of repair. Worse, some lighting fails to achieve its aim — as, for instance, much security lighting. A 1998 study commissioned by the United States Department of Justice concluded there is no statistically significant

(continued on page 42)

BAD URBAN LIGHTING robs most city dwellers of a dark night sky, not to mention they're paying extra in taxes because poorly designed lights waste electricity. Read on for some ideas on how to fight the growing problem of light pollution where you live. MICHAEL E. BAKICH

The bright night sky

Satellite imagery of the nighttime Earth lets scientists construct a global light pollution map. Most *Astronomy* readers, and others in the developed world, live within one of the bright spots, while the dark land-areas are usually rural, thinly populated, or poor. Backyard astronomers gravitate toward the dark regions, even as some cities take steps to help slow the spread of light pollution.

CANADA has a number of "Dark Sky Preserves," where lighting ordinances are enforced aggressively. Other locations are beginning to follow suit. Even cities are taking notice, urged on by Canadian amateur astronomers.

BELGIUM has an annual National Light Pollution Awareness Day to promote a better nighttime environment.

IRELAND and **ARGENTINA** are the latest countries to have affiliate organizations join IDA. IDA sections — for the distribution of educational information — are being set up within both countries.

THE UNITED STATES now has a number of state ordinances dealing with nighttime lighting, with more coming. Many communities are enacting such ordinances to help control the adverse impact on their nighttime environment. IDA is producing a "model lighting ordinance" to help these communities in their efforts. What is your community doing?

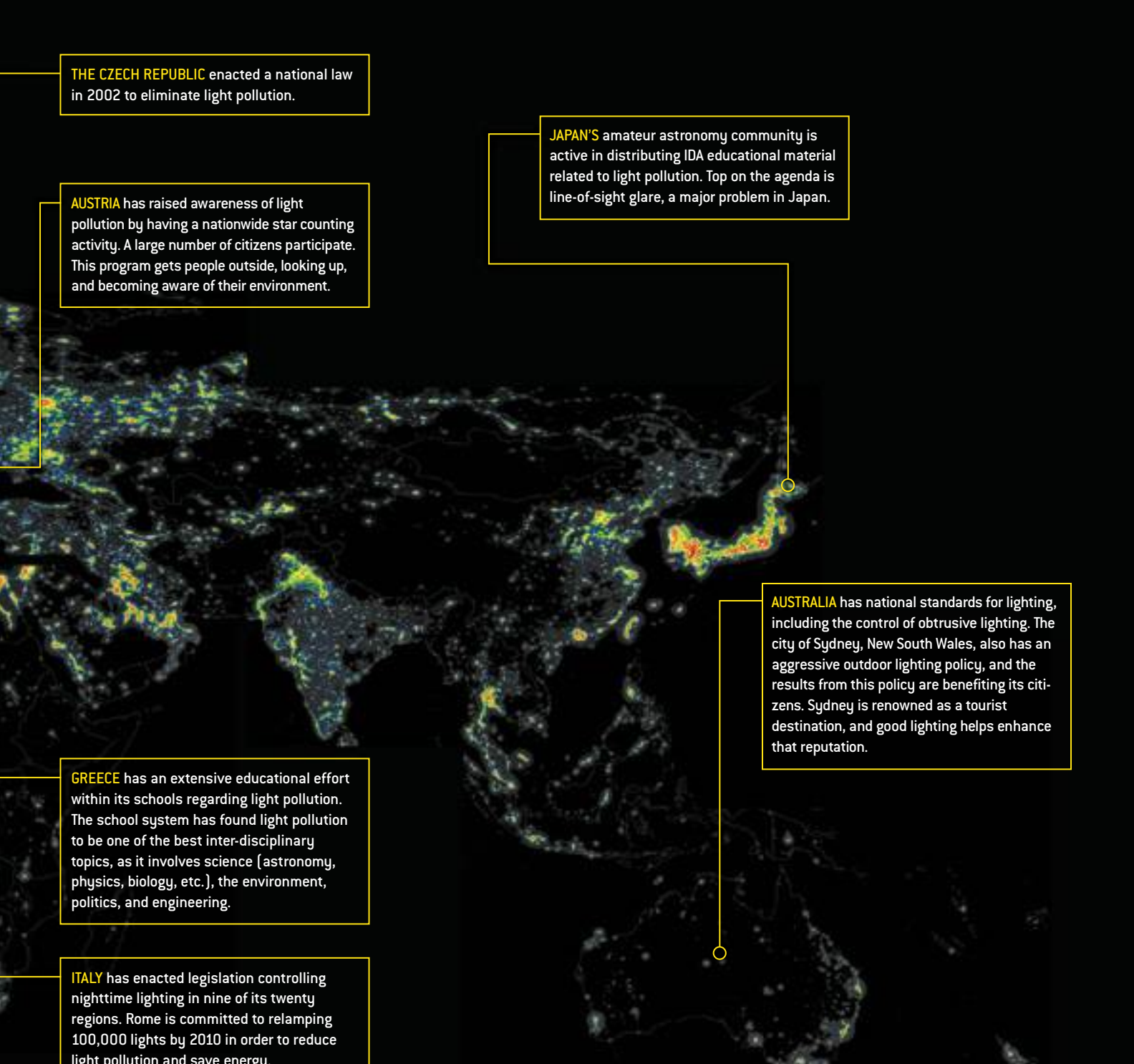
TUCSON, ARIZONA, has had outdoor lighting ordinances since 1970. The ordinances save money, enhance businesses, and help preserve the beauty of the night sky. Tucson has grown since 1970 to more than 800,000 people, yet the sky glow at the major observatories near Tucson has increased very little over that period.

FLAGSTAFF, ARIZONA, was recently proclaimed by IDA to be the first ever Dark-Sky City, having taken many steps to reduce light pollution.

CHILE has national legislation for a number of its regions to promote quality lighting and to preserve the night environment. The government recognizes the economic value of such activities.

ENGLAND has many organizations involved in educational efforts geared toward better nighttime lighting. The Campaign for Dark Skies is an organization allied with IDA that works with the Institute of Lighting Engineers, the Council for the Protection of the Rural Environment, and various governmental bodies in these efforts.

ALL LIGHT POLLUTION MAPS: P. CINZANO, F. FALCHI (UNIVERSITY OF PADOVA), C. D. ELVIDGE (NOAA NATIONAL GEOPHYSICAL DATA CENTER, BOULDER); COPYRIGHT ROYAL ASTRONOMICAL SOCIETY; REPRODUCED FROM THE MONTHLY NOTICES OF THE RAS BY PERMISSION OF BLACKWELL SCIENCE.



THE CZECH REPUBLIC enacted a national law in 2002 to eliminate light pollution.

AUSTRIA has raised awareness of light pollution by having a nationwide star counting activity. A large number of citizens participate. This program gets people outside, looking up, and becoming aware of their environment.

JAPAN'S amateur astronomy community is active in distributing IDA educational material related to light pollution. Top on the agenda is line-of-sight glare, a major problem in Japan.

GREECE has an extensive educational effort within its schools regarding light pollution. The school system has found light pollution to be one of the best inter-disciplinary topics, as it involves science (astronomy, physics, biology, etc.), the environment, politics, and engineering.

ITALY has enacted legislation controlling nighttime lighting in nine of its twenty regions. Rome is committed to relamping 100,000 lights by 2010 in order to reduce light pollution and save energy.

AUSTRALIA has national standards for lighting, including the control of obtrusive lighting. The city of Sydney, New South Wales, also has an aggressive outdoor lighting policy, and the results from this policy are benefiting its citizens. Sydney is renowned as a tourist destination, and good lighting helps enhance that reputation.

/// THE INTERNATIONAL DARK-SKY ASSOCIATION

The International Dark-Sky Association (IDA) was incorporated in 1988 with the goal of preserving dark skies and improving the nighttime environment for everyone. It has about 11,000 members from each of the fifty states and from more than seventy other countries. IDA has contacts with national and international organizations that deal with outdoor lighting or that have an interest in the issue. IDA staff and members are actively involved with these organizations. Lighting standards

are changing as a result of their efforts, which bodes well for the future. IDA's web site (www.darksky.org) contains lots of material: information sheets, slides, images, *PowerPoint* presentations, and links to important sites. "Many members contact IDA for advice on promoting good lighting and for resources," says Dave Crawford, IDA president. "We need to attract more members if we are to make a continued positive impact on the problem. As the saying goes, think globally, act locally."

(continued from page 39)

evidence that street lighting affects the level of crime. The study found, however, that increased lighting decreases the fear of crime. In essence, poor lighting doesn't aid security; it simply makes you feel safer.

In 2002, CNN reported on a study conducted by scientists at the University of Padua, Italy, and the United States National Oceanic and Atmospheric Administration. The researchers found that a truly dark, starry sky is unavailable to two-thirds of the world's population. This includes 99 percent of people in the continental United States and Western Europe.

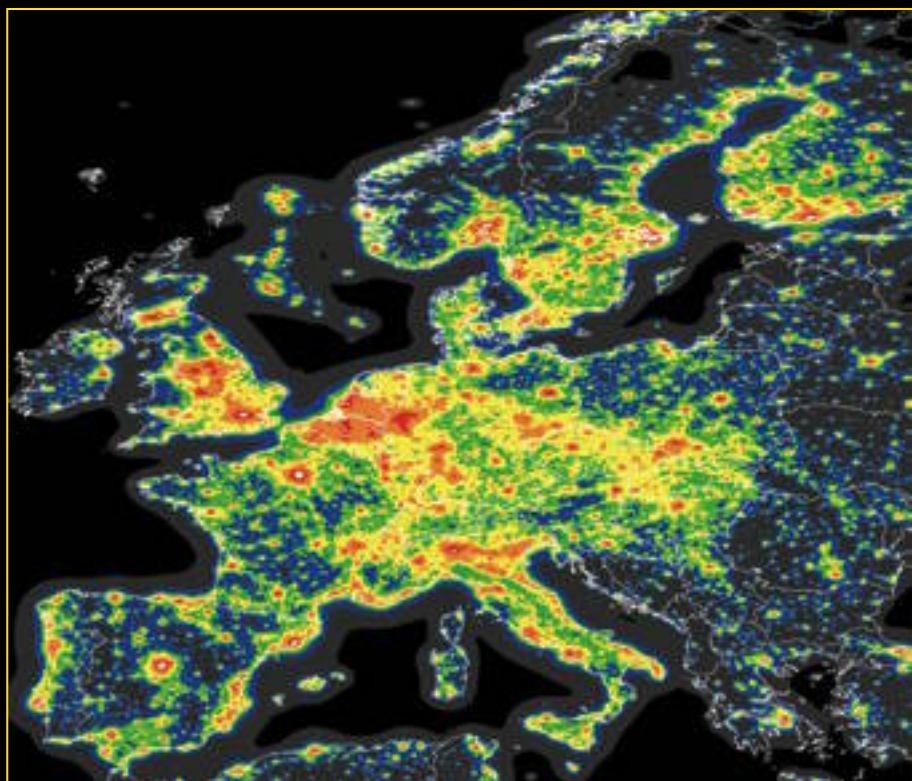
The study also measured for the first time how light degrades the view of the stars in specific places around the globe. The researchers discovered that in some regions, true night never occurs because of illumination from lights located in nearby cities and towns. The study also concluded 40 percent of the population of the United States and 10 percent of the world's people live where it never gets dark enough for eyes to become dark-adapted.

What your eyes need

Dark adaptation — your eyes becoming fully adjusted to low light levels — is the key to the night-sky experience. It's what makes the starlit heavens take your breath away. Once a person's eyes become dark-adapted, lower levels of illumination than those currently being used outdoors at night become acceptable. The greatest human-related problems arise when eyes must move from dark to light and back again rapidly. Under these conditions, eyes really don't function well in either situation.

The problem worsens with age, too. Older people encounter difficulties with overly bright nighttime lighting. Changes within the eye due to age, such as diminished dark-adaptation

Michael E. Bakich is an associate editor of *Astronomy*.



NO DARK SKIES EXIST IN CENTRAL EUROPE, where one city's sky glow merges with its neighbor's. Only sparsely populated regions, and relatively poor rural ones, have dark skies. (The bright lights in the middle of the North Sea come from oil-well drilling platforms.)

speed, can prove dangerous. Entering a car under a brilliantly lit service-station canopy and then driving out onto a highway with much dimmer lights (or none) places an elderly driver — not to mention anyone or anything in the way — at a terrible disadvantage. Older eyes are also more sensitive to glare, particularly from bluer-colored light sources.

The eye, especially at night, does not see blue light well. Thus, bluish light sources like mercury-vapor lamps must consume many more watts to look as bright as yellowish sources such as sodium-vapor lamps. The International Dark-Sky Association (IDA) estimates that the United States alone wastes

more than one billion dollars each year in energy costs for unnecessary lighting.

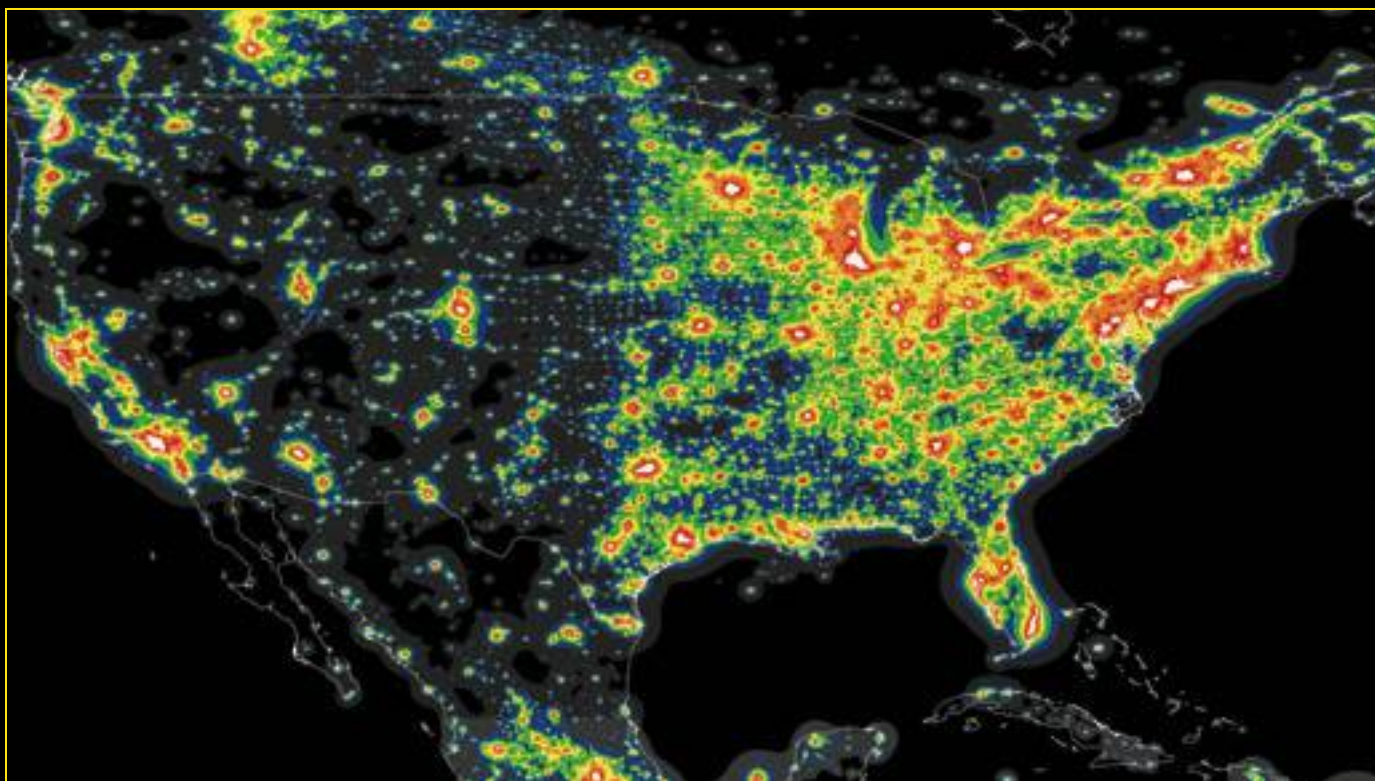
Steps you can take

I have a bit of personal experience in helping to enact a lighting ordinance in El Paso, Texas, where I lived for several years before joining *Astronomy*. (At press time, the City Council had yet to vote on the ordinance — but it's been in their hands for only 2½ years!) The people most responsible for El Paso's movement toward an effective lighting ordinance are John Peterson and Cory Stone, director and assistant director of the Gene Roddenberry Planetarium. They have a four-part strategy

/// SUCCESS STORY

In June 2003, the United States Border Patrol activated twenty light towers along the Arizona border with Mexico. Each tower had three, extremely bright metal-halide lights, which caused considerable sky glow and light trespass. At the request of nearby residents, the Border Patrol has shielded and redirected the lights. They are no longer distinguishable from the existing border lights. IMAGES: DOUG SNYDER





NORTH AMERICA BLAZES with light, especially in the eastern states, where dark skies hardly exist at all. Pockets of darkness grow, however, as one travels west. In particular, notice how city lights decrease west of about the 95th meridian. That longitude, roughly where annual rainfall drops below 20 inches, is often considered the beginning of the West.

they recommend for any astronomy club or individuals wishing to work within the political system to reduce light pollution.

First, focus on economics. The best advice is to leave the astronomy-related arguments at home. Emphasize what everyone understands: money. You can mention other benefits such as security and night-sky issues, but dollars (or euros) get the most attention.

Second, make it easy for the politicians. Provide copies of lighting ordinances from other cities, statistics and economic benefit reports, engineering and safety reports, etc. Then go the extra mile by composing a first draft of the ordinance your group is proposing.

Third, get many people involved and keep them interested. Draft letters that can be mailed or e-mailed to all members of the governing body. Make the messages short and non-confrontational, and be sure each writer identifies herself or himself as a voter. Write letters to your local newspaper and to TV and radio stations. Get schools involved. Host astronomy events in town and pass out light-pollution information to everyone who attends.

Finally, choose a “point person” who has a pleasant manner, is patient and not easily irritated, and who will be able to attend the meetings of the governing authority. The key lies in being low-key: Avoid a vocal activist, however

helpful she or he has been in your club. Such people often come across as confrontational.

It's good for everyone

As fervent as we are in attempting to preserve (or return to) a dark night sky, it's important to remind people that light pollution is bad for more than just the astronomical community.

As IDA's *Lighting Code Handbook* says, “Bad lighting hurts everyone. It starts a cascade of negative consequences — beginning with the loss of our views of the heavens, continuing through falling levels of safety and utility, irritation of neighbors and wildlife, disturbance of the rhythms of day and night that are vital to many natural systems, damage to the aesthetic appearance of our communities, wasted monetary and natural resources used to produce wasted light, and increased air pollution and carbon dioxide levels from wasted fossil fuels. There is nothing good that comes from bad lighting.”

Dave Crawford, president of IDA, says, “Light pollution is not the inevitable price of progress. In fact it's the reverse — a sign of inefficiency and harm to the environment.” ■

/// THREE WAYS TO SAVE ENERGY (AND MONEY)

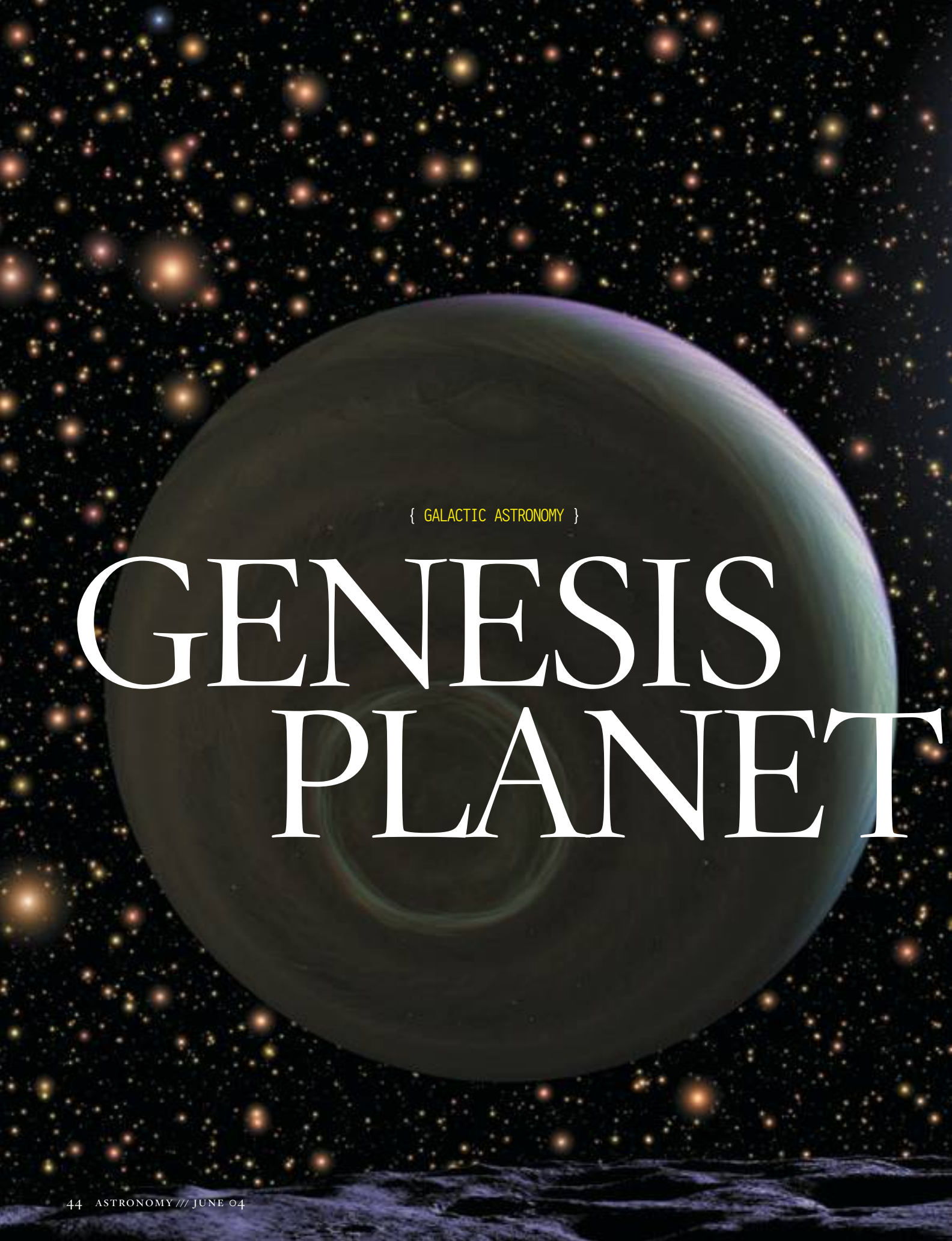
1) Turn down the lights. When we use lights brighter than those recommended by engineers, we waste money because human eyes quickly adapt to the higher levels of illumination. For additional energy savings, install lower wattage bulbs in areas inside and outside your home or business (such as hallways and yards) where bright lights are not needed for specific activities.

2) Pick the right lamp for the job. Selecting high-pressure sodium lights saves 40 percent in operating costs over metal-halide lamps and 150 percent over mercury-vapor lights.

3) Shield all lights. Installing full cutoff shields will direct the light to where it's needed, reducing dangerous glare — with the side benefit of preserving the sky and allowing lower wattage lamps to be used.



To learn more about combating light pollution, visit www.astronomy.com/toc



{ GALACTIC ASTRONOMY }

GENESIS PLANET



Astronomers have discovered a planet inside a globular cluster, suggesting planets — and perhaps life — formed far earlier than thought.

/// BY RAY VILLARD AND ADOLF SCHALLER

EVER SINCE THE EARLY 1990s, when astronomers discovered the first planet orbiting a distant star, they have been surprised by what has turned up. Now, with at least 110 such planets known, the strange variety of extrasolar planets has been confirmed many times over. Astronomers have found planets with highly eccentric orbits, massive planets orbiting next to their parent stars, even planets circling pulsars.

Yet one recent discovery sticks out like a sore thumb. This gas-giant planet sets five new records in the quest to uncover extrasolar planets. It ranks as the oldest, the farthest, the first to orbit a tight binary star system, the first located in a globular star cluster, and the only one to reside in a region highly deficient in the heavy elements thought necessary for building planets. It is the one known world that will have profound implications for our understanding of the emergence of planetary systems and life in the very early universe.

The object has been dubbed the “Methuselah Planet.” Like the biblical patriarch, it was born not long after the universe’s creation and has existed for an enormous amount of time. This planet formed a staggering 13 billion years ago — less than a billion years after the Big Bang — which makes it nearly three times the age of Earth. The ancient world lies 5,600 light-years away, in globular cluster M4 in the constellation Scorpius. The planet was already fully formed when our fledgling galaxy was still growing into a vast spiral star city, long before the Sun ever ignited, and even before the first scraps of interstellar gas and dust began to condense into what would become our solar system. Every other extrasolar planet discovered so far dwells in our stellar backyard, within our galaxy’s younger disk population.

You also could call this mysterious giant the “Survivor Planet.” For the past 13 billion years, the planet has managed to stay confined within M4 despite the rough-and-tumble environment of a globular star cluster, where stars swarm around violently in a nonstop game of interstellar billiards. The planet endured the death of its parent sun and a collision with a binary star system.

THE GAS-GIANT GENESIS PLANET orbits nearly 2 billion miles from a tight binary system consisting of a pulsar and white dwarf (the brighter of the pair). The group, seen here from the surface of a hypothetical moon, lies in globular cluster M4, although well outside its core. ADOLF SCHALLER



Following a brief game of stellar musical chairs, the planet now orbits a binary system that constantly bathes it in blistering X rays from a spun-up neutron star and ultraviolet light from that star's stripped-down white dwarf companion.

But perhaps the title "Genesis Planet" best characterizes this world because it could represent the first generation of planets that formed in the universe. The first forms of life in the cosmos may have appeared on such early-bloomer planets — and had 13 billion years to evolve. When the first primitive organic chemistry on Earth was trying to self-replicate, advanced life-forms on first-generation planets may have been building starships.

The discovery suggests that very early in its history, the universe was more efficient at making planets than astronomers

ever thought possible. The construction material for planets back then was much more scarce. The Genesis Planet formed around a star that may have had only 5 percent of the heavy-element abundance in our solar system. These heavy elements were scarcer in the early universe because the first "star factories" had just begun forging carbon, nitrogen, oxygen, silicon, and the like in their nuclear furnaces. This implies that our galaxy could be teeming with more planets than earlier estimates because the process of forming planetary systems may have been common long ago. Even more importantly — where there are planets, there could be life.

Location, location, location

In 1999, astronomers first used the Hubble Space Telescope to go hunting for planets in globular star clusters. Hubble's unblinking eye watched 34,000 stars in the nearby cluster 47 Tucanae for eight consecutive

days. The researchers tried to detect if any star showed a momentary drop in brightness as a close-orbiting planet passed in front of it, an event called a transit. Statistically, they expected to see a few transits. Hubble didn't find a single one.

This fishing trip bolstered the idea that globular clusters might not have formed planets because they lack many heavy elements. Surveys reinforced this idea by showing that all the known planet-bearing stars are richer than our Sun in heavy elements. And systems with more of these elements are more likely to have planets.

A decade before Hubble's search, however, a pulsar called PSR B1620-26 in M4 first betrayed the Genesis Planet's presence. Observations of changes in the clock-like precision of the object's radio pulses showed the pulsar has a slight but complex wobble. This indicated that two orbiting objects gravitationally tug on the pulsar.



To take a trip inside a dense globular cluster, visit www.astronomy.com/toc



A FEW BILLION YEARS AGO, the Genesis Planet and its parent star (behind the planet) entered M4's core. This system soon will interact with a neutron star/white dwarf binary, the bluish object seen just to the planet's upper left that stands out from the cluster's solar-type stars and red giants. ADOLF SCHALLER

One of the companions, a white dwarf, was identified in the 1990s. But the second glows too faintly to be seen. Astronomers debated its identity for more than a decade.

Radio observations of the pulsar showed that the orbit of the invisible companion was tilted from the orbital plane of the white dwarf and neutron star. But astronomers did not know how either orbit was inclined to our line of sight. Therefore, estimates about the invisible object's mass varied widely. If it were more than 10 Jupiter masses, it would be a brown dwarf, an object that forms like a star but doesn't have enough mass to ignite nuclear fusion.

The planet's orbital tilt was nailed in 2003, when Steinn Sigurdsson of Pennsylvania State University and his colleagues used an archival Hubble survey of white dwarfs in M4 to accurately measure the color and temperature of the one orbiting PSR B1620-26. This allowed astronomers to deduce both the white dwarf's age and

mass. Knowing the mass constrained the true tilt of its orbit as seen from Earth, which allowed the astronomers to constrain the tilt of the Genesis Planet's orbit as well. They then calculated the object's mass to be a mere 2.5 Jupiter masses. This unequivocally makes it an extrasolar planet.

Odd couple

Hubble observations of M4's oldest and coolest white dwarfs made by the University of British Columbia's Harvey Richer suggest the cluster formed in a furious burst of star formation about 700 million years after the Big Bang. Within a few million years of this firestorm, hundreds of short-lived, high-mass stars detonated as supernovae. Some of the supernovae gave birth to rapidly spinning neutron stars and their cousins, pulsars, the collapsed remnants of the massive progenitor stars.

Supernova shock waves and galelike stellar winds eventually blasted away all

the cluster's residual gas and dust, squelching any further starbirth. They also probably tore apart some fraction of the protoplanetary disks that surrounded neighboring lower-mass stars.

Back then, a 2.5-Jupiter-mass planet had just started condensing in a disk encircling a solar-mass star at the cluster's periphery. It probably formed at a distance from the star comparable to Jupiter's distance from the Sun. This would have left room for a terrestrial planet to form in the star's "habitable zone," where oceans of liquid water could remain stable for billions of years.

Deeper inside the cluster, pulsars were scattered among the supernova remnants. Many of the pulsars held on to lower-mass binary companion stars. One of these systems was destined to rendezvous with the Genesis Planet and its Sun-like star. But this would have to wait billions of years as the planet and its parent star followed a slow, looping orbit around M4's center.



CIRCLE MARKS THE SPOT of the binary star system tucked deep inside M4. The system consists of a millisecond pulsar and a white dwarf (which emits most of the visible radiation picked up in this Hubble image) along with the invisible Genesis Planet. NASA AND HARVEY RICHER (UNIVERSITY OF BRITISH COLUMBIA)

Only about 2 or 3 billion years ago, just as early single-celled life was enriching Earth's atmosphere with oxygen, the star and planet plunged through the cluster's core like a wayward comet. They barreled toward a binary system containing an ancient neutron star, which had long since spun-down and ceased flickering as a pulsar. Gravitational interaction between the two star systems ejected the neutron star's original companion. In this "do-si-do," the planet found itself in a 1.7-billion-mile orbit around the new stellar couple.

Roughly 500 million years ago, when the first multicelled life was emerging on Earth, the Genesis Planet's original aging parent

Ray Villard is public information officer at the Space Telescope Science Institute in Baltimore, Maryland. Adolf Schaller is an artist living in Gays Mills, Wisconsin.

star ballooned into a red giant. The giant spilled its outer atmosphere onto the neutron star. Robbing momentum from its bulky companion, the refueled neutron star spun up to the revolution speed of a kitchen blender. It reawakened as a millisecond pulsar, irradiating the Genesis Planet with a lethal dose of X rays. By spilling onto the neutron star, the giant had been stripped down to a core weighing just 0.35 solar mass. After less than 100 million years, the red giant shrank to a white dwarf with a helium atmosphere.

Today, the neutron star contains about three-quarters of the entire system's mass but measures only several miles across. That gives it a volume just two billionths that of its white dwarf companion. The system's barycenter, the pivot point between the two co-orbiting stars, lies about a third of the way from the neutron star to the

white dwarf. Ironically, this leaves the mass-challenged Genesis Planet as the physically largest object in the system, having a volume almost 600 times greater than both stars combined.

Astronomer Alan Boss of the Carnegie Institution of Washington sees the discovery as remarkable evidence that the planet formation process is much more efficient and robust than previously imagined. In the conventional model, dust and gas settle into a disk encircling a newborn star. The dust coagulates to make embryonic cores that gravitationally sweep up additional disk debris and build planets. But the M4 discovery may bolster ideas that more than one recipe can make gas-giant planets. Boss favors a disk-instability mechanism where clumps of gas quickly cool and contract to make Jupiter-size planets. This method avoids the need to build up planets slowly from rocky seed cores.



GLOBULAR CLUSTER M4 began life some 13 billion years ago as a starburst region. Hundreds of supernovae and their overlapping remnants dispersed the heavy elements necessary to build planets and life, although the Genesis Planet had already formed in M4's outskirts. A high-energy jet blasted from the Milky Way's growing core, home to an active black hole. ADOLF SCHALLER

The bottom line is that the various mechanisms for forming planets are not mutually exclusive, and more than one could contribute to a single planetary system's construction. If true, this suggests that ancient planetary systems could contain rocky, terrestrial-type planets like Earth. It also seems reasonable to assume that ancient gas-giant planets could be circled by systems of solid moons as big as our Sun's terrestrial planets.

Life in a young galaxy

This line of reasoning has far-reaching implications for the abundance of life in space. If enough carbon and other elements existed to make planets, then there should have been enough material for making life as we know it. Astrobiology research during the past two decades shows life is aggressive and opportunistic in using basic elements to build complexity. If planets appeared so

early in the universe, then life-forms far more advanced than us might well exist.

Because the Genesis Planet is a gas giant like Jupiter, it has no solid surface and no niche for life as we know it to emerge. But if the planet has rocky moons, they might have been abodes for life. And there's no reason to think that the Genesis Planet started out as the star's solitary companion. Other gas giants and terrestrial planets could have completed a complex system.

It's not unreasonable to speculate that carbon-based life might have emerged on one of these hypothetical terrestrial worlds. If a stable and long-lived technological civilization arose, it would have had time to anticipate the catastrophic effects of the system's suicide dive into the globular cluster's core. Alien scientists should have realized that the planets would be reshuffled in the binary star collision. They also should have realized the neutron star would fire up

and blast any surviving planets with X rays. The approaching doomsday would have required daunting feats of astroengineering to preserve the civilization. This might have led to an interstellar migration from the system. Or perhaps the inhabitants would have tried to colonize the subsurface regions of any suitable moons orbiting the gas giant.

If anyone did live in the Genesis Planet's system, they would have had a ringside seat to watch the Milky Way Galaxy evolve over billions of years. Perhaps M4 alien astronomers using powerful telescopes briefly noted the birth of our solar system. We probably would have been only a passing curiosity for them. Such a civilization would have perused protoplanetary systems innumerable times with their godlike view from above the galaxy's plane. For them, planet birth in our sprawling young Orion spiral arm was not so long ago, in a galaxy not terribly far away. ■



JUNE 04

For the first time since 1882, Venus will pass directly in front of the Sun.

While that signal event rules daytime observing, the night sky belongs to two comets.

Venus transits! Comets rule!

Two wonderful comets grace June's evening sky. Although their glory nights have passed, C/2002 T7 (LINEAR) and C/2001 Q4 (NEAT) still should be performing better than any comet since Hale-Bopp seven years ago. Astronomy clubs and planetaria around the world will be hosting public viewing events — make sure to take advantage of them if you don't own a telescope.

For the best looks, plan on heading to the countryside, at least an hour's drive away from any major city. The view through a telescope from the city won't compare with a binocular view far from the deleterious effects of pollution, haze, and streetlights. The sight of a beautiful comet — let alone two — against the deepening twilight will remain with you for the rest of your life. Try to avoid the first few evenings of June when the Full Moon casts a glow almost as obtrusive as city lights. By the 4th, however, the Moon rises during twilight, and we'll have an ever-increasing window of darkness because it rises about an hour later each night.

Comet C/2002 T7 hugs the west-southwestern horizon below the bright beacon Jupiter. Catch it early in June before it slumps into obscurity around midmonth. In contrast, C/2001 Q4 shines a bit brighter than T7 and climbs higher in the northwest, toward the bowl of the Big Dipper. C/2002 T7 appeared



NOCTILUCENT CLOUDS form high in Earth's atmosphere and occur most often around the summer solstice. OSCAR VAN DONGEN

brighter than C/2001 Q4 this spring because it came closer to both the Sun and Earth, but now its orbit has taken it farther from us and the source of illumination.

If you can tear your eyes away from the comets, look for yellow Saturn slipping away in the evening twilight. It will return to view in a couple months, rising in the east before dawn.

If you can believe it, Mars remains with us a full ten

months after its grand peak last August. You may need binoculars to pick up the faint orange dot, located to the upper left of Saturn. As always, it loses the solar system race with Earth, and it soon will drop behind the Sun at the opposite end of the track.

Jupiter fares better than Saturn or Mars, staying above the twilight glow all month. Its days are numbered as well, however, and this will be the last month to get great views of

the giant planet through a telescope. It will disappear in the twilight by the end of August.

With all the time you'll be spending outside watching the comets in the fading twilight, scan the northern horizon for a special atmospheric phenomenon: noctilucent clouds.

These wispy clouds form only in summer at the rarified altitude of 50 miles (80 km). Meteorologists think they consist of ice crystals that form when water vapor condenses on the cores of burnt-out meteoric grains. Typically seen only at high northern latitudes, in the past few years they've been sighted farther south than 45° north latitude — perhaps a sign of climate change.

The Moon reaches its full phase on the night of June 2/3, within a few hours of its closest approach to Earth this year. Ocean tides are governed largely by the Moon's closeness to Earth and whether it lines up with the Sun at new or full phase. Put the two together and we'll see some of the highest and lowest tides of the year.

The Moon returns to the evening sky as a crescent on the 19th, located about a binocular field to the right of inconspicuous Mars. It pairs up in a beautiful conjunction with Jupiter on the 23rd, then passes near blue-white Spica on the 26th.

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Celestron's renown NexStar GPS computerized Schmidt-Cassegrain telescopes continue to draw admiration and praise for their **unsurpassed optical quality, state-of-the-art design and engineering, and ease of use. With fork mounts, drive bases and optical systems manufactured in our U.S.A. facility**, Celestron's NexStar GPS series continues to set the standard for features and performance *again* with the optional StarBright XLT High Performance Optical System, and our newest innovation: **NexRemote**.

NexRemote puts all of the functions and features of our NexStar hand control onto your PC or laptop.

With NexRemote, you can remotely set up and control your NexStar GPS, and it's **compatible with most hand-held GPS units**. It can be used with popular planetarium software programs. You can create multiple custom tours. **An audible voice describes celestial objects as they are selected from the hand controller, and you can even use a hand-held wireless controller to operate your telescope!** These are just a few of NexRemote's great features. Best of all, it's **FREE** with all NexStar GPS models.

NexStar GPS Quality Features At A Glance

Here are just a few of the design and engineering features that have earned the NexStar GPS series worldwide admiration and respect:

Quality Components

- Pittman Lo-Cog® brush commutated DC motors; made in U.S.A.
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- Stainless steel worm shaft
- Precision annealed Pyrex® primary and secondary mirrors
- Carbon Fiber Tube - 1/4 the thermal expansion of aluminum

Intelligent Design

- Built-in GPS receiver, magnetic compass and internal altitude switch
- Internal Slip Ring to eliminate power cables from wrapping
- Auxiliary ports located on the rotating base
- Ergonomic design for easy transport
- Optical Tube Assembly Mounting Rails
- Unique roller bearing and shaft design creates an effective 10" diameter Azimuth bearing for maximum stability

Software

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**NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guide (#94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included.

***120V AC Adapter included for U.S.A. and Canada only.

NexStar 9.25 GPS**

NexStar 8 GPS

	NexStar 8 GPS Model 11052	NexStar 9.25 GPS Model 11056	NexStar 11 GPS Model 11053
Eyepiece (70x)	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	No
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	\$2169	\$2799	\$3224
StarBright XLT*	\$2324	\$3019	\$3504
Shipping & Handling	\$95	\$115	\$125

NEW Celestron StarBright® XLT™ High Performance Optical Coatings Outperform The Competitor's UHTC.

StarBright XLT — An Optical System Breakthrough! Celestron has taken its renowned StarBright technology to an even higher level of light transmission with the introduction of our new optional StarBright XLT High Performance Optical Coating System.

StarBright XLT Optical System Design — You'll See The Light.

One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use and for CCD/Photographic imaging.

Celestron StarBright XLT: The Bottom Line.

- 11% brighter than UHTC across the spectrum from 400nm to 750nm. (See Fig.#1)
- 11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings (See Fig.#2)
- 6% brighter than UHTC to the dark-adapted eye (See Fig.#3)
- 16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.

Coming Out of the Dark — StarBright XLT Performance Where It Counts

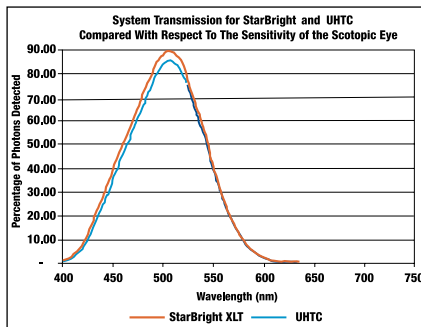


Fig #3: The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a 6% improvement over UHTC for visual observing.*

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	5%
Helium II and O ₃	496	88.0	84.0	5%
O ₃	501	88.0	84.3	5%
Center of dark adapted vision	510	88.7	84.8	5%
Helium I	588	88.0	81.6	8%
N ₂	655	84.0	73.8	14%
N ₂ and H-alpha	658	84.0	73.0	15%
Sulfur II	673	83.0	72.0	15%

System Transmission for StarBright XLT and UHTC

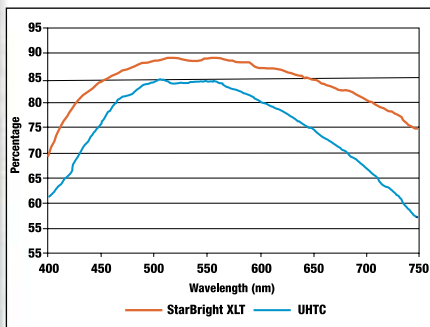


Fig #1: This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.*

CCD Imaging — It's All In The Photons

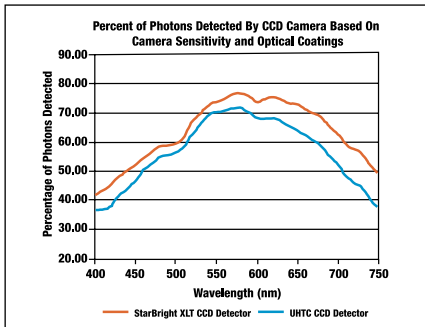


Fig #2: StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.*

UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: www.celestron.com/starbrightxlt.*

***Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.**

The StarBright XLT System — What makes it different makes it better. — There are three major components that make up our StarBright XLT high transmission optical system design:

- 1. Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), SiO₂ (quartz), TiO₂ (titanium dioxide), and SiO₂. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
- 2. Multi-layer anti-reflective coatings** — Made from precise layers of MgF₂ (magnesium fluoride), and HfO₂ (hafnium oxide). A rare element costing nearly

\$2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.

- 3. High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with optional StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. **Water white glass transmits about 90.5% without anti-reflective coatings.** That is 3.5% better transmission than uncoated soda lime glass. **When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!**

StarBright XLT Pricing

All 8" Schmidt-Cassegrain Products.....	\$125
All 9.25" Schmidt-Cassegrain Products.....	\$175
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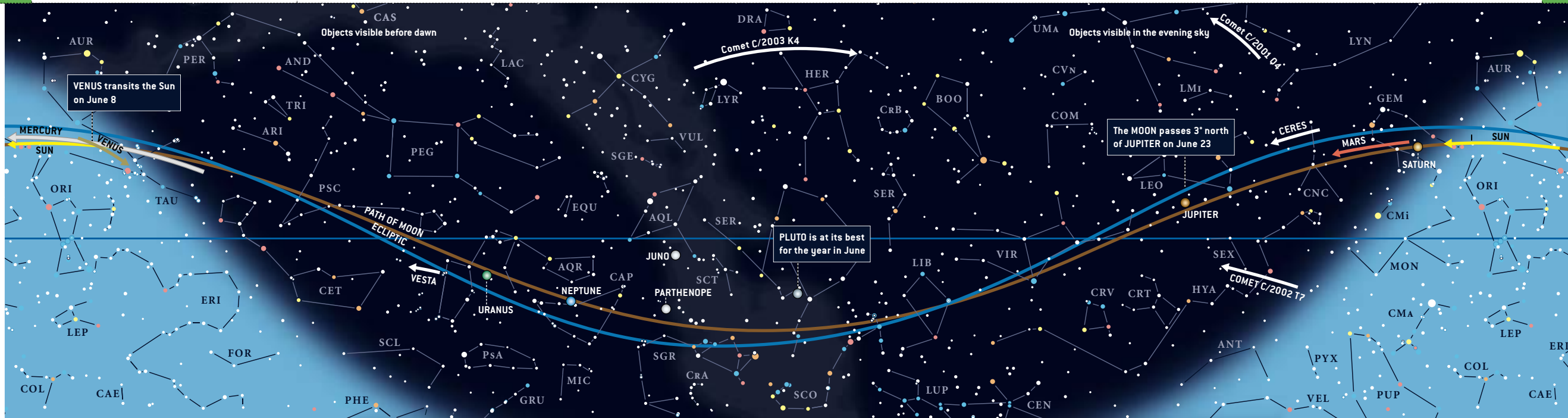
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Planets this month

This map unfolds the entire night sky from sunset [at right] until sunrise [at left]. Arrows and colored dots show motions and locations of solar system objects during the month.

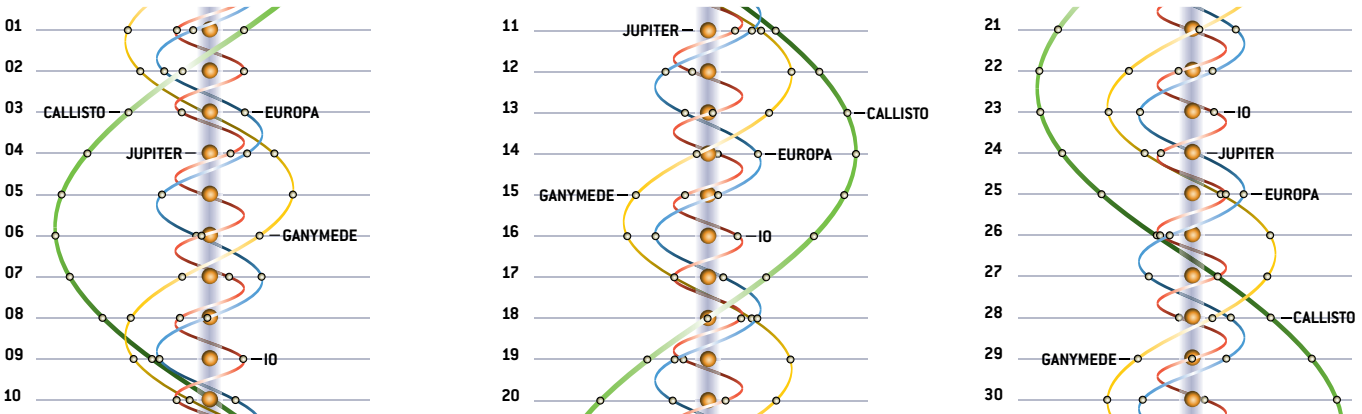


To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	June 1	June 30	June 15	June 30	June 15	June 15	June 15	June 15	June 15	June 15
Magnitude	-0.5	-1.0	-4.0	-4.4	1.8	-1.9	0.1	5.8	7.9	13.8
Angular Size	6.0"	5.3"	56.4"	47.1"	3.8"	35.4"	16.6"	3.6"	2.3"	0.1"
Illumination	72%	88%	2%	13%	98%	99%	100%	100%	100%	100%
Distance (AU) from Earth	1.122	1.258	0.296	0.355	2.449	5.571	9.992	19.720	29.420	29.805
Distance (AU) from Sun	0.370	0.351	0.727	0.728	1.652	5.434	9.041	20.048	30.071	30.807
Right Ascension (2000.0)	3h19.6m	7h33.2m	4h50.9m	4h34.2m	7h46.0m	10h52.6m	6h59.6m	22h35.0m	21h10.4m	17h22.3m
Declination (2000.0)	16°16'	23°38'	20°47'	17°53'	22°28'	8°28'	22°26'	-9°46'	-16°21"	-14°14"

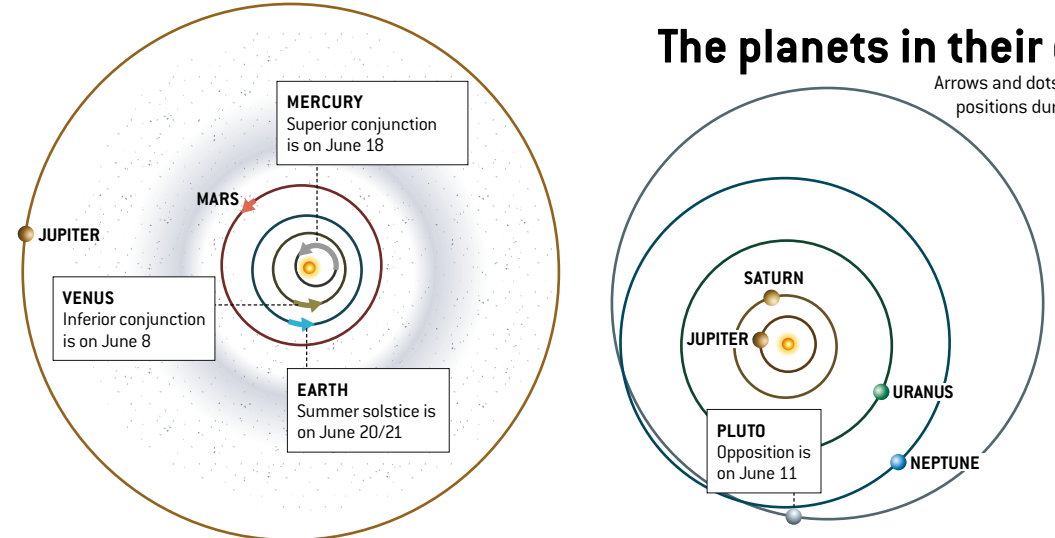
Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.



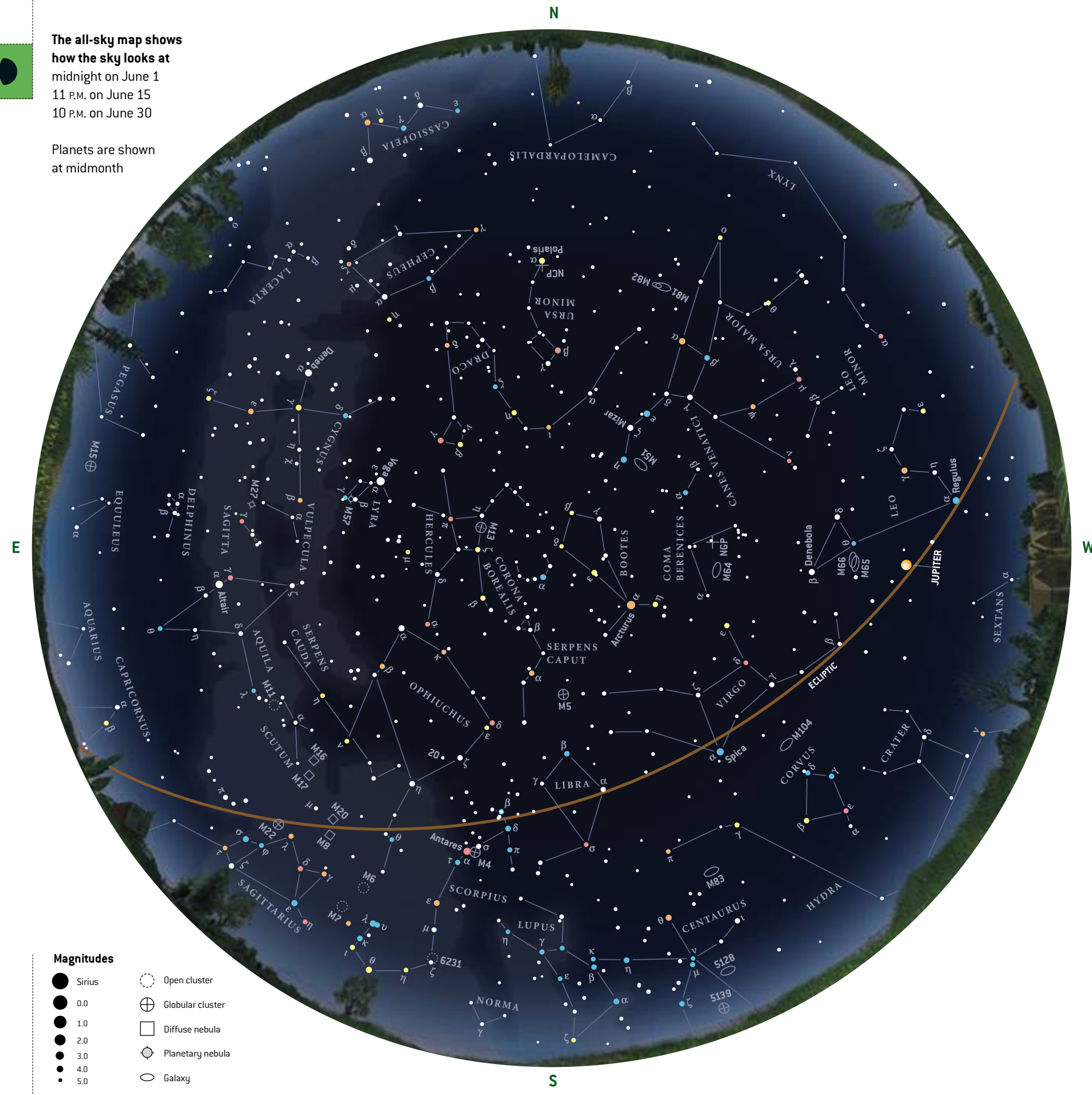
The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows
how the sky looks at
midnight on June 1
11 P.M. on June 15
10 P.M. on June 30

Planets are shown
at midmonth



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The new Advanced Series and Advanced Series **Computerized GoTo** telescopes have been designed to offer the novice or more advanced user a selection of models with the **features, quality and value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace and accessory tray for

superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt-Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector. There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's **precision matched and hand-figured optical systems.**

CG-5 Mount — Precision engineered for stability.

Additional Specifications — Computerized Models

Hand Control	Double line, 16 character Crystal Display, 19 fiber optic backlit LED buttons
Motor Type	DC Servo motors with encoders, both axes
Max Slew Speed	4"/second
Software Precision	24bit, 0.08 arcsec calculation
Hand Control Ports	RS-232 communication port on hand control
Motor Ports	Aux Port, Autoguider Ports
Tracking Rates	Sidereal, Solar and Lunar
Tracking Modes	EQ North & EQ South
Alignment Procedures	AutoAlign, 2-Star Alignment, Quick Align
Database	40,000+ objects, 400 user defined programmable objects

Our new **CG-5 German Equatorial Mount** has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger and more substantial legs** that provide excellent damping characteristics for

more stable views. The CG-5 also has a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments.

GoTo convenience and GPS compatibility for precision accuracy.

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included **NexStar[®] computer control system** and utilize many of the same features as Celestron's most advanced GoTo telescopes like an **Autoguider port** for long exposure deep sky astro-photography. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963)**. It allows your telescope to pinpoint your position on the Earth, the date and time, and makes the alignment process faster and easier than ever before!

These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4° per second, you will be able to instantly point to any of the celestial objects in the database.

◀ C9/1/4-SGT
(#11046)

◀ C10-NGT
(#11048)

Specifications — All Advanced Series Telescopes

	21010 C4-R	11071/11072 C5-S	31006 C8-R	31011/31010 C8-S	19325/11004 C8-S	31008/31002 C8-R	11043/11046 C9 1/4-S	11043/11048 C10-N
Optical Design	102mm (4.0") reflector	127mm (5.0") Schmidt-Cassegrain	115mm (4.5") reflector	115mm (4.5") reflector	202mm (8.0") Schmidt-Cassegrain	202mm (8.0") reflector	230mm (9.1") Schmidt-Cassegrain	254mm (10.0") reflector
Focal Length	1000mm F10	1250mm F10	750mm F5	1250mm F8	2020mm F10	1000mm F5	2300mm F10	1000mm F4.7
Field of View	6°30'	6°30'	6°30'	6°30'	6°30'	9°30'	6°30'	9°30'
Mount	CG-4 Equatorial	CG-5 Equatorial	CG-4 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial
Eyepiece	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)	1-1/4" - 25mm (20x)
Star Diagonal	1-1/4"	1-1/4"	n/a	1-1/4"	1-1/4"	n/a	1-1/4"	n/a
Accessory Tray	yes	yes	yes	yes	yes	yes	yes	yes
Tripod	Aluminum	2" Stainless Steel	Aluminum	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel
CG Mount	The Sky Level I	The Sky Level I	The Sky Level I	The Sky Level I	The Sky Level I	The Sky Level I	The Sky Level I	The Sky Level I

PRICING: C10-NGT (#11048): \$1,149 + \$95 S&H; C10-N (#11047): \$849 + \$75 S&H; C9/1/4-SGT (#11046): \$1,699 + \$105 S&H; C9/1/4-S (#11045): \$1,399 + \$85 S&H; C8-SGT (#11026): \$1,299 + \$75 S&H; C8-S (#11025): \$999 + \$85 S&H; C8-NGT (#31062): \$949 + \$85 S&H; C8-N (#31061): \$649 + \$65 S&H; C6-RGT (#21020): \$999 + \$95 S&H; C6-R (#21019): \$799 + \$75 S&H; C6-N (#31056): \$399 + \$50 S&H; C5-SGT (#11072): \$1,099 + \$75 S&H; C5-S (#11071): \$849 + \$65 S&H; C4-R (#21016): \$399 + \$40 S&H

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OMNI[®] Eyepieces — 1 1/4"

- Focal lengths — 4mm, 6mm, 9mm, 12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52° (43° for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges



NEW!

4mm.....	\$ 44.00
6mm.....	\$ 44.00
9mm.....	\$ 44.00
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15mm.....	\$ 44.00
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32mm.....	\$ 54.00
40mm.....	\$ 54.00

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OMNI[®] Barlow Lens — 1 1/4"

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- Fully multi-coated
- Short tube design



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NEW!



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- Focal lengths — 26mm, 32mm, and 40mm
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- **Fully multi-coated**
- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux[®] Eyepieces — 1 1/4"

- Focal lengths — 6mm, 10mm, 25mm, and 40mm
 - Traditional Plössl optical design
 - Fully-coated
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|-------------------|-------------------|
| 2": | 1-1/4": |
| 26mm.....\$ 69.00 | 6mm.....\$ 34.00 |
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19mm.....	\$149.00
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- Five-element guiding eyepiece
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- Multicoated optics for increased contrast
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Stereo Binocular Viewer.....\$649.00

X-Cel[®] Eyepieces — 1 1/4"

- **6-element optical design utilizing ED glass**
- Focal lengths — 2.3mm, 5mm, 8mm, 10mm, 12.5mm, 18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal — little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case



NEW!

2.3mm.....	\$ 69.00
5mm.....	\$ 69.00
8mm.....	\$ 69.00
10mm.....	\$ 69.00
12.5mm.....	\$ 69.00
18mm.....	\$ 69.00
21mm.....	\$ 69.00
25mm.....	\$ 69.00

Filter & Eyepiece Kit

- Five Superior Grade Plössl Eyepieces — 1.25"
- Barlow Lens — 2x 1.25"
- Six Colored Eyepiece (Planetary) Filters
- Moon Filter — 1.25"
- Aluminum Carrying Case



Filter & Eyepiece Kit.....\$ 149.00

Ultima[®] 2x Barlow — 1 1/4"

- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated



1-1/4" Ultima Barlow.....\$ 79.00

Microguide Eyepiece — 1 1/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
- Measure position angles and separation of double stars



Microguide Eyepiece 1-1/4".....\$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool



Collimation Eyepiece.....\$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure



Radial Guider.....\$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C9-1/4, C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- 1/6.3 for C5, C8, C9-1/4 and C11 telescopes and 1/7 for the C14 telescope



Reducer/Corrector.....\$139.00

2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
- Multicoated mirror
- Smooth mechanics that are precision manufactured for reliability



2" Mirror Diagonal.....\$ 89.00

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- 12-volt rechargeable power supply
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- 3V, 6V and 9V outputs for accessories
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- Booster terminal on rear side
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- Cigarette lighter adapter included
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NEW!

Power Tank.....\$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground



Vibration Suppression Pads (Set of 3).....\$ 59.00

Contrast-Booster Filter — 1 1/4"

by Baader

- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter.....\$ 49.00



Model A — for 1-1/4" eyepieces Model B — for backthreads of SC's
LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4".....\$ 69.00
LPR Filter Model B.....\$ 99.00

1 1/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze



1-1/4" Polarizing Filter Set.....\$ 39.00

Eyepiece Filter Sets — 1 1/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue



#94119-10 (21, 80A, 15, Polarizing).....\$ 44.00
#94119-20 (12, 25, 56, ND-25).....\$ 44.00
#94119-30 (23A, 38A, 58, ND-50).....\$ 44.00
#94119-40 (8, ND-13, 47, 82A).....\$ 44.00

Night Vision Flashlight

- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).



Night Vision Flashlight.....\$ 19.00

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THE DEEP SKY

As if two comets in one month are not enough, a third one, C/2003 K4 (LINEAR), soars through northern Hercules and dodges Draco on June evenings.

Double up in Draco

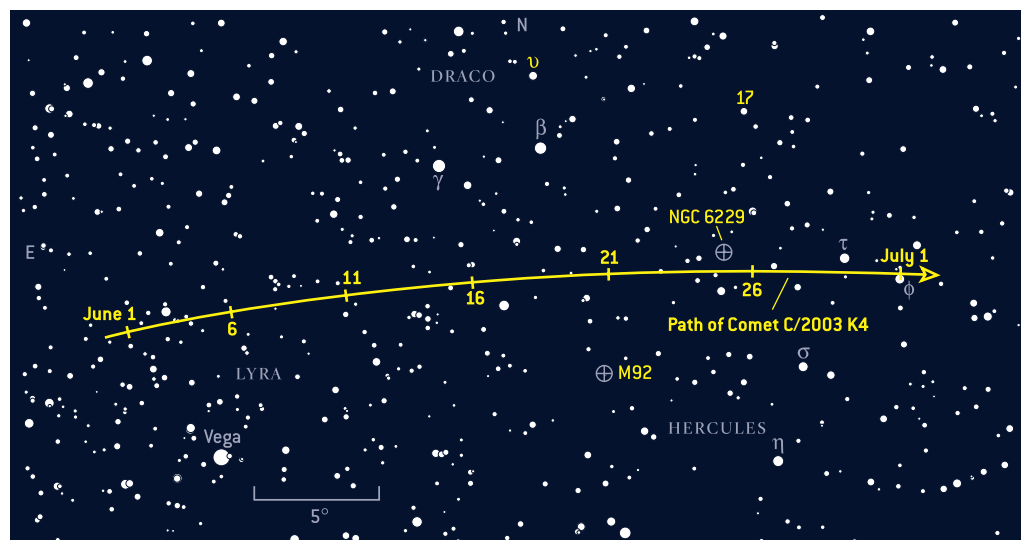
North of the brilliant white star Vega, the eyes of Draco the Dragon burn through the veil of urban skyglow. Slightly poleward from the eyes sits Nu (ν) Draconis, a perfectly equal pair of 4.9-magnitude stars that makes a nice binocular target. From our point of view this month, Saturn and its rings span 38", so they would slide comfortably through the 62" gap that separates the lovely white doublet.

The Dragon holds another binocular gem in 16 and 17 Draconis. Draw a line through Draco's eyes and shift upward twice the span of its head to find these 5.1- and 5.5-magnitude luminaries that stand 90" apart. Small telescopes easily show the 6.4-magnitude star that completes this triple system. One hundred fifty years ago, Admiral Smyth described this star as a "pale lilac" located 3.4" from the "pale yellow" 17 Draconis.

Globular grazing

Slide from Nu through Beta (β) Draconis and down three more lengths and you'll land on Messier 92 in Hercules, a bright, compact globular cluster that's home to a few hundred thousand stars. At magnitude 6.4, M92 can just be glimpsed with the naked

Martin Ratcliffe is former president of the International Planetarium Society. **Alister Ling** is a meteorologist for Environment Canada.



eye under very good skies. Find it first with binoculars to be sure the few photons of light tickling your retina come from this round ball of stars located some 27,000 light-years from Earth.

M92 is a favorite target of deep-sky observers — some even rank it ahead of the better known globular in Hercules, M13. Although M13 looks impressive because of its sheer size and number of stars, M92 packs in more and more stars as you peer closer to its core. A 4-inch telescope just shows its supergiant stars, while a 10- to 12-inch scope pulls in hundreds more, revealing its great aesthetic appeal.

Despite the increasing moonlight toward the end of June, it will be worth your while to follow Comet C/2003 K4 (LINEAR). This chunk of primordial ice and dust slides less than 1° south of globular



GLOBULAR CLUSTER M92 may play second fiddle to M13 among globulars in Hercules, but it's still worth a long look. MACE HOOLEY

cluster NGC 6229 on the evening of the 25th. The two should appear similar in size, but the 8th-magnitude comet should glow a magnitude brighter than the globular. It's an excellent chance to study the different structures of each object. Both will have diffuse edges, but the comet's sunward side should have a sharper

boundary where the impinging solar wind creates a bow wave.

Although similar to M92 in true size, NGC 6229 appears smaller and fainter because it lies 100,000 light-years from Earth. Its stars glow three magnitudes fainter than M92's, meaning a 12-inch scope barely reveals granulation under a dark, steady sky.

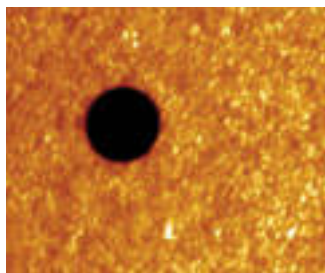
THE PLANETS

The number of planets visible during the evening hours dwindles during June, but the month's highlight comes when Venus makes the transition from evening to morning by passing directly in front of the Sun.

No one alive has ever seen a **transit of Venus** — the last one occurred on December 6, 1882. The entire June 8 event can be viewed from across Europe, Asia, and Africa, with observers in Australasia seeing the beginning of the transit and people in eastern North and South America witnessing the end.

The silhouette of the second planet from the Sun takes approximately six hours to cross the Sun's disk. From North America, the final two hours or so will be visible from New England and eastern Canada after sunrise. The farther west you live, the less you'll see, and observers in the western third of the continent will miss out entirely.

Just like during a solar eclipse, you should never view a transit directly without a good solar filter. For complete observing details, see "Viewing Venus in transit" on page 74. Transits of Venus occur in pairs eight years apart, with the next one occurring June 6, 2012.



WHEN VENUS TRANSITS THE SUN on June 8 (for the first time in 122 years), it will appear far bigger than Mercury did during this 2003 transit. ROYAL SWEDISH ACADEMY OF SCIENCES

Your descendants, however, will have to wait until the year 2117 to view another.

After the transit, a challenge will be to see how soon you can spot **Venus** in the dawn sky. On June 16, Venus rises with a slim crescent Moon in a bright sky 30 minutes before sunrise. On that morning, Venus lies 4° below the Moon. Seen through a telescope, the planet presents a large, thin crescent that spans nearly 1'.

By the end of June, Venus shines brilliantly at magnitude -4.4. It has climbed higher remarkably fast, lying 12° above the eastern horizon 30 minutes before the Sun rises. The planet's disk then appears 47" across and 13 percent lit.

Moving back to the evening sky, **Saturn** and **Mars** lie one above the other in Gemini. You'll find Saturn 10° above the west-northwestern horizon an hour after sunset during the first week of June.

Saturn appears the brighter of the two, shining at magnitude 0.1. Mars, which lies 4° above Saturn, glows five times fainter at magnitude 1.8. Castor and Pollux, the bright "twin" stars in Gemini that now lie above the two planets, outshine Mars at magnitudes 1.6 and 1.1, respectively.

Early June marks your last chance to view the ringed planet before the Sun's glow swallows it near month's end. However, with a spacecraft from Earth arriving in its vicinity next month, our view



of Saturn will not be lost. The international Cassini spacecraft is scheduled to enter orbit around Saturn on July 1, beginning what promises to be the next exciting chapter in solar system exploration.

In the meantime, enjoy your last telescopic views of the disk and rings until Saturn reappears in the morning sky in late July. The major axis of the rings currently spans 38", while Saturn's disk measures 17" across. Titan, Saturn's largest moon, shines at magnitude 8.3 and can be picked out with a small telescope.

Although Saturn becomes lost in the bright twilight before the end of June, Mars remains in view as it pulls away from Saturn. The Red Planet's tiny disk now measures less than 4" across. On the evening of June 19, it forms a line with Castor and Pollux, with a fine

crescent Moon standing 2° to the lower left of Pollux.

As dusk falls, you can find **Jupiter** halfway up in the southwestern sky. Shining at magnitude -1.9, the planet easily surpasses the stars of its host constellation, Leo, as well as every other point of light in the evening sky. Leo's brightest star, Regulus, stands about 10° to the lower right of the planet. On June 23, Jupiter appears four Moon-widths below a 6-day-old crescent Moon.

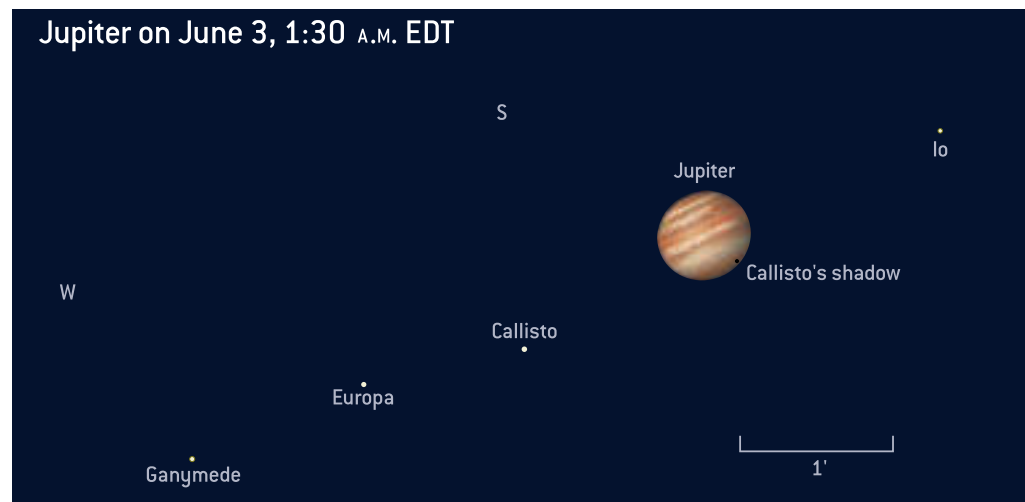
Although Jupiter's apparent diameter has shrunk by 10" since its March peak, it's still a hefty 35". Jupiter never fails to show detail on its cloudy face. Small telescopes (2 inches, or 60mm, in aperture) easily show the parallel pair of dark equatorial belts, one on either side of the equator. Four-inch (100mm) or larger telescopes reveal significantly more detail.

Given steady air above you and some patience, you'll notice subtle spots dotted across the disk and fine, delicate swirls extending from the dark belts.

Jupiter passed east quadrature, when the positions of the planet, Earth, and the Sun formed a right angle, at the end of May. This means Jupiter's shadow now extends well to the east of the planet as we view it. So as the four Galilean moons orbit Jupiter and pass into the planet's shadow, we get good views of each eclipse. Both Ganymede and Callisto orbit far enough from Jupiter that we see each moon disappear and reappear clear of the planet's eastern limb.

Callisto's three-year series of occultations, eclipses, and transits soon will come to an end. It's the only major moon of Jupiter whose orbit takes it far enough out of the plane of Jupiter's orbit that it sometimes avoids passing through the planet's shadow. In September, while Jupiter is lost in the Sun's glare, the series concludes and no more events will be seen for another three years. The next series will begin on January 9, 2008. (See "Jupiter's satellites" on page 62 for event times this month.)

Distant **Pluto** reaches opposition on June 11. By definition, this places it due south and highest in the sky at local midnight. Glowing dimly at magnitude 13.8, however, you'll still need at least an 8-inch scope and an extremely dark sky to detect it visually. A digital camera attached to your telescope will have an easier time picking up the solar system's ninth planet. If you plan



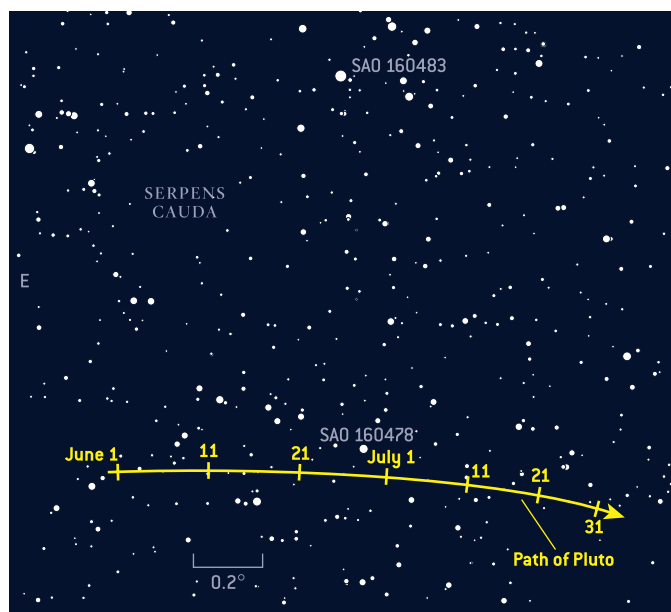
to search for Pluto, use the star chart at right to home in on the planet's position in southwestern Serpens Cauda. The chart shows stars down to magnitude 14.0, which should be enough to help you identify the planet. To confirm a sighting, sketch or photograph the field of view on one night and repeat the process a night or two later. Pluto is the object that appears to move.

Neptune rises before midnight by the middle of June. Glowing at magnitude 7.9, it's well within reach of binoculars, although you need to know exactly where to look. It currently lies less than 1.5° northeast of Theta (θ) Capricorni, a 4.1-magnitude star in the north-central part of the Sea Goat. Between Neptune and Theta lies a 6.9-magnitude star, perhaps easily confused with Neptune except for its brighter appearance. Neptune moves closer to this star throughout June, passing due north of it at month's end. With only 0.2° separating the pair, identifying Neptune will be easier than usual.

Neptune's twin, **Uranus**, rises an hour after its sibling. It's well placed in central Aquarius near 4.8-magnitude Sigma (σ) Aquarii. Grab your binoculars and locate Sigma. Then note 58 Aquarii, a fainter star immediately to its southeast. For reference, these two stars lie 0.3° apart. On June 1, Uranus stands 1.5° northeast of Sigma, while a 6.8-magnitude star lies 0.3° northwest of Uranus. Uranus remains nearly

stationary with respect to the background stars throughout June, and its position will not change significantly until July.

Innermost **Mercury** makes a brief appearance in the evening sky at the end of June. It passes 2° north of Saturn on the 26th, but both planets lie only 10° from the Sun so the conjunction will be invisible. On the 30th, Mercury lies 5° south (to the lower left) of Pollux in Gemini in a bright twilight sky.



METEORS AND MOONS

A meteor shower with a history of surprises may produce a good show in late July. At the same time, sunrise highlights the brightest lunar feature.

An uncertain shower

The unexpectedly strong return in 1998 of the June Boötid meteor shower confirmed its connection to its parent comet, Pons-Winnecke. Observers recorded rates as high as 100 meteors per hour for a number of hours. The period of activity typically runs from June 26 to July 2. Current predictions, as usual fraught with uncertainty, indicate peak activity should be centered around 1h Universal Time on June 27 (9 P.M. EDT on June 26). The waxing gibbous Moon sets just in time for European observers, who are favored this year for viewing any potential activity. But North Americans should be out on the morning of the 27th as well, in case the predictions are off by a few hours.

A brilliant crater

As June begins, the Sun rises over the Moon's Oceanus Procellarum and one of its most celebrated craters, Aristarchus. This magnificent, 25-mile-wide (40 km) crater — the brightest feature on the Moon — sits on an elevated plateau itself rich with detail. The inner walls of Aristarchus are heavily terraced, and the floor of the crater sits 2 miles below its rim. As the Sun rises higher over the crater, it illuminates a slightly off-center mountain. Attentive observers will notice the crater's off-round appearance, a result of the low-inclination impact that created Aristarchus. Confirmation of this comes from bright rays extending to the southwest that show up best under high Sun angles. The



THE CRATER ARISTARCHUS

[arrow] — the brightest feature on the Moon — lies on an intriguing plateau that also features the sinuous rille Schröter's Valley.

FROM THE CONSOLIDATED LUNAR ATLAS (LPL/UA)

crater is relatively young, less than 500 million years old.

The ancient crater Herodotus, with its large, flat floor, sits adjacent to Aristarchus. The most prominent nearby feature is the largest sinuous rille on the Moon, Schröter's Valley. Its course winds 100 miles (160 km) across the elevated plateau. A deep crater located at the southern end of the rille, dubbed the Cobra's Head, appears to be the source of a lava eruption that formed the rille. The Sun sets over Aristarchus three days before New Moon, providing yet another nice view of this complex and fascinating region.

Jupiter's satellites

The rare occultations, eclipses, and transits involving the outer Galilean moon, Callisto, are nearing their end. During each 12-year orbit of Jupiter around the Sun, only two such series occur. The current one began in late 2001 and continues until September 2004, but none will be visible after July

/// JUNE CALLISTO EVENTS

	{ UT }	{ EST }	{ Event }
2nd	16h53m 20h31m	12:53 16:31	IV.Tr.I. IV.Tr.E.
3rd	5h10m 7h51m	1:10 3:51	IV.Sh.I. IV.Sh.E.
10th		21:29	IV.Oc.D.*
11th	1h29m 5h11m 14h03m 16h39m	1:11 10:03 12:39	IV.Oc.D.* IV.Oc.R. IV.Ec.D. IV.Ec.R.
19th	11h21m 14h58m 23h13m	7:21 10:58 19:13 21:44	IV.Tr.I. IV.Tr.E. IV.Sh.I. IV.Sh.E.*
20th	1h44m		IV.Tr.E.*
27th	20h22m	16:22 20:01	IV.Oc.D. IV.Sh.E.*
28th	0h01m 8h10m 10h33m	4:10 6:33	IV.Oc.R.* IV.Ec.D. IV.Ec.R.

*Events that occur on either side of midnight are shown twice.



COMETS AND ASTEROIDS

Although now past their peaks, comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) remain prime targets for observers using their naked eyes, binoculars, or a telescope.

Hair on the Bear

The analogy may sound odd, but it's not a bad one. When the ancient Greeks saw fuzzy apparitions in the sky with long streamers, they dubbed them *kometes*, which literally means "long haired." The hair, of course, refers to the tail that usually flows from a bright comet. Whether inbound or outbound, a comet's tail always points away from the Sun because solar radiation pushes the comet's dust away and the solar wind carries away the comet's gas. In the case of C/2001 Q4, the tail now points straight up from the north-western horizon for observers in the Northern Hemisphere. The Bear refers to Q4's host constellation, Ursa Major.

As long as you're not standing downtown or under a streetlight, you should be able to see the core of Q4 without optical aid. At roughly 4th magnitude (no one knows for sure how bright a comet will glow), it should be fairly noticeable under a dark sky. Binoculars give the best overall view because they will show the bright core as well as the entire tail against the deepening twilight and starry background. Telescopes work best at showing detail in the tail and inner coma.

If you imagine a hole in the lower right corner of the Big Dipper's bowl (Beta [β] Ursa Majoris), follow the water pouring downward and you will run across the comet. By

the end of June, it will have faded to 6th magnitude but will be easy to find in the same binocular field as Beta.

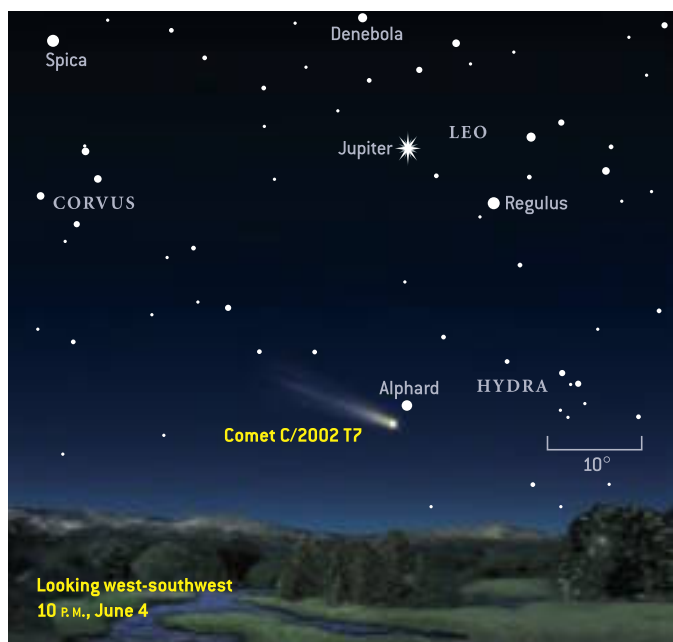
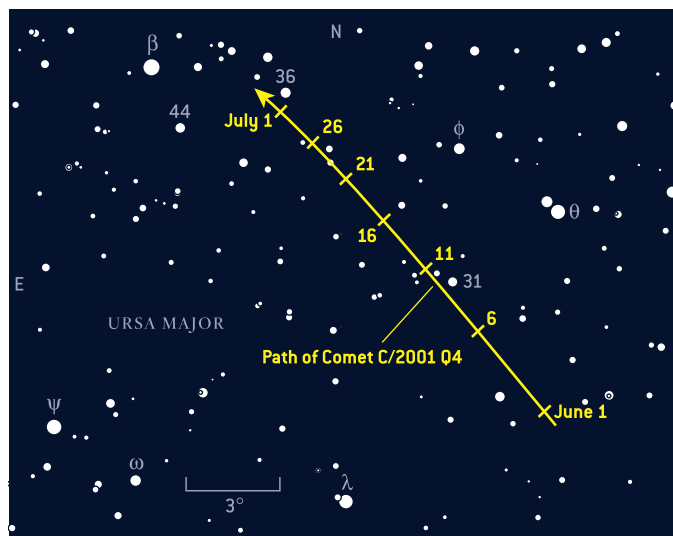
Last days of T7

When it comes to comets, it's definitely better to burn out than fade away. Which will it be for C/2002 T7? Because it comes closer to the Sun than Venus, there's a slight chance the comet will break up and flare in brightness before dissolving into dust. If that happens, T7's show will be more spectacular than Q4's.

Look for the comet during evening twilight, when it lies low in the west-southwest beneath Jupiter. The farther north you live, the closer to the horizon T7 will be. Its tail could span as much as 10°, or roughly two binocular fields, stretched out almost parallel to the horizon and pointing south, away from the Sun.

Although the dust tail normally appears a pale yellow-white because dust reflects sunlight, the tail could look even more yellow because its light has to pass through a lot of Earth's atmosphere. Find an observing site with an unobstructed southwestern horizon to get a good view.

If you live in the southern tier of states or, even better, in the Southern Hemisphere, pump up the power for T7 on June 21. Sharing the comet's field of view will be the Spindle Galaxy, NGC 3115. This bright, 8.9-magnitude spiral galaxy



appears edge-on to our line of sight, giving it an elongated appearance in the eyepiece.

From the Northern Hemisphere, make the most of any clear evening in the second week of June to view T7

because after that, the comet's increasing distance from Earth and its drop into the horizon murk will herald the end of its apparition. Millions of years from now, T7 will be ejected from the solar system. ■

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Selling you the right telescope means listening carefully to what *you* want to see and do with a telescope – to match your needs and dreams to your budget. It means answering your questions truthfully and fully. It means taking the time to explain your options. It means using our experience – a staff total of over 160 years of experience using and selling telescopes – to make sure that you get the scope and accessories that work together properly and do what you want to do . . . the scope and accessories that are right for *you*.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs (and

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Optional Meade Sky Assurance™ extended service contracts extend your scope warranty to three or five years – *or even longer!*

Here are the LX200GPS scopes we ship from our stock:

7" Maksutov-Cassegrain	.....	\$2695 ⁰⁰
7" Maksutov-Cassegrain, w/UHTC	.....	\$2845 ⁰⁰
8" Schmidt-Cassegrain	.....	\$2195 ⁰⁰
8" Schmidt-Cassegrain, w/UHTC	.....	\$2370 ⁰⁰
10" Schmidt-Cassegrain	.....	\$2745 ⁰⁰
10" Schmidt-Cassegrain, w/UHTC	.....	\$2980 ⁰⁰

Here are the LX200GPS scopes Meade ships from the factory due to their weight:

12" Schmidt-Cassegrain	.....	\$3595 ⁰⁰
12" Schmidt-Cassegrain, w/UHTC	.....	\$3890 ⁰⁰
14" Schmidt-Cassegrain	.....	\$4695 ⁰⁰
14" Schmidt-Cassegrain, w/UHTC	.....	\$5045 ⁰⁰
16" SCT, w/altazimuth pier and UHTC		\$15,645 ⁰⁰
16" SCT, w/equatorial pier and UHTC		\$15,845 ⁰⁰

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Meade ETX Mks now come with tripod and Autostar!

Best-selling **Meade ETX Maksutov-Cassegrains** now include an adjustable height tripod and Autostar computer – for less than the former cost of the same components bought separately. A tripod is a costly option with a competitor's 4" go-to Mak. Prices start at only \$595 for a full-featured 3.5"

go-to scope that has everything you need to start observing as soon as you get it. Each 3.5" to 5" ETX has a tripod, computer, eyepiece, finder, and more. Optional UHTC optical coatings can give you images up to 20% brighter so you can see 20% more of the Universe. The optional Meade Sky Assurance™ extended service plan can extend your ETX warranty to three or five years – *or even longer!*

New Celestron Dobs are packed with features and value.

The new **Celestron StarHopper Dobs** are loaded with useful features. Instead of Teflon or plastic pads sliding on Formica to support the scopes, roller bearings with dozens of support points ride on a broad azimuth track for smooth hitch-free horizontal motion. Altitude bearings ride on nylon rollers for an equally smooth vertical motion. There's a variable tension altitude clutch to compensate for different eyepiece weights. The finderscope (6x30mm on the 6"; 9x50mm on the 8" through 12") is mounted in an

easy-to-align quick release bracket. The 8" through 12" scopes use a 2" metal rack and pinion focuser (with 1.25" adapter) and come with a 2" 32mm E-Lux eyepiece (the 6" scope has a 1.25" metal rack and pinion focuser and 25mm Plössl). The 10" and 12" scopes have a built-in battery-operated cooling fan for their primary mirrors. All have fast cool-down metal tubes and BK7 optical glass mirrors.

Here are the prices for the fully-equipped Celestron StarHopper Dobsonians.

6" f/8 Celestron StarHopper	....	\$279 ⁰⁰ + \$49 freight
8" f/6 Celestron StarHopper	.....	\$369 ⁰⁰ + \$59 freight
10" f/5 Celestron StarHopper	.....	\$499 ⁰⁰ + \$69 freight
12" f/5 Celestron StarHopper	.....	\$899 ⁰⁰ + \$99 freight

I've really enjoyed the Dob I received from you people and plan on doing much more business in the future as you were more

interested in filling my needs than just making a quick sale. Thank you for your help.

Customer Quote of the Month #147

Meade go-to . . . at prices you can afford.

Why pay for an ordinary telescope when you can get a fully computerized Meade LX200 for the same price? The go-to LX200 is the biggest advance in an affordable mount since the German mount was invented in the early 1800s!

You won't spend your time hunting for deep space objects with a 5" or 6" LX200 refractor or a fast 6", 8", or 10" reflector (with either standard or optional UHTC optics). A few touches on the built-in Autostar computer send your

scope speeding to any of 30,000 stars and objects and tracks it as you observe. You'll spend more of your time looking at celestial objects and less time looking for them with an LX200.

Each is complete with adjustable height tripod, dual motor drives, accessory tray, finder-scope, eyepiece, and Autostar computer. Each LX200 qualifies for optional Meade Sky Assurance™ extended service.

We actually stock TeleVue.

To sell seven figures worth of TeleVue a year, you have to keep a lot of it in stock so you can ship fast and keep your customers happy. We do keep a big inventory on hand, so our customers are very happy. Others may say they carry TeleVue, but we *actually* keep TeleVue in stock. Lots of it.

Here are a few of the TeleVue refractors that we keep in stock for immediate shipment.
Pronto, 2.7" f/6.8 semi-apo \$1120⁰⁰
TV-76, 3" f/6.3 apo 1675⁰⁰
TV-85, 3.35" f/7 apo 2080⁰⁰
TV-102, 4" f/8.6 apo 2635⁰⁰
Renaissance 102, 4" f/8.6 brass apo 3175⁰⁰
NP-101, 4" f/5.4 apo 3595⁰⁰

All of the above refractors come without a mount, but include an eyepiece (except the NP-101), an enhanced aluminum or 99% reflectivity Everbrite star diagonal, a carrying case, and

Does your dealer?

a tube ring for mounting. Optical tubes only, without these accessories (such as the new **TV-60** apochromatic at \$795), are also available from stock.

As for accessories, we stock them all. For example, here are a few of the newest eyepieces from TeleVue that we can ship today.

2-4mm 1.25" Nagler zoom	.....	\$395 ⁰⁰
2.5mm 1.25" Nagler Type 6	.....	280 ⁰⁰
3.5mm 1.25" Nagler Type 6	.....	280 ⁰⁰
11mm 1.25" Nagler Type 6	.....	280 ⁰⁰
20mm 2" Nagler Type 5	.....	440 ⁰⁰
41mm 2" Panoptic	.....	495 ⁰⁰

Whether it's a Gibraltar, Panoramic, or TelePod mount; a Sky Tour computer; a Nagler, Radian, Panoptic, or Plössl eyepiece; a Powermate or Barlow; an Everbrite 99% reflectivity star diagonal; a light pollution filter, or a BinoVue – if it's TeleVue, it's in stock.

Why wait for another dealer to order your scope?

We'll ship your Meade LX90 from our stock . . .

The **Meade LX90** lets you enjoy go-to astronomy for not a lot of money. The 8" LX90 with standard optical coatings is only \$1695. UHTC (Ultra High Transmission Coatings) optics give you up to 20% brighter images for only \$175 additional. The LX90 has a heavy-duty adjustable height tripod, 26mm

Super Plössl eyepiece, Autostar computer with 30,223 star and object memory, 8 x 50mm finder.

There's no need to wait for another dealer to order an LX90 for you to enjoy. We usually have dozens of LX90s in stock at all times, so you can probably get your LX90 with little or no delay.

The LX90 qualifies for the optional Meade Sky Assurance™ extended service contracts.

Right angle finders at new lower prices.

We stock **Antares** 8 x 50mm and 12 x 80mm right angle finders at new lower prices from \$79⁹⁵ to \$239⁹⁵. Choose from Celestron black, Meade blue, or a gloss white in either standard mirror-image versions or erect right-reading models that show you the sky the way it ap-

pears on star charts. Each is available with either dark crosshairs or a unique built-in cordless red disk illuminator. Economical optional quick release mounting brackets are also available.

Are these the best Schmidt-Cassegrain optics?

Many observers think that the **NexStar 9¼ GPS** has the sharpest and highest contrast optics that Celestron has ever made. In addition to extraordinary 9.25" f/10 optics, you get all of the features you expect from a GPS scope plus some unique features that are unavailable in other scopes.

For example, its optical tube is carbon fi-

ber – not ordinary aluminum. Carbon fiber's lower thermal expansion coefficient means you'll never worry about temperature-caused focus changes during photography or high power planetary observing. In addition, you get the brighter images of Starbright multicoated optics and a two-year warranty at *no extra cost!* You can even add optional state-of-the-art StarBright XL T-coatings for Celestron's brightest images ever. The best SCT optics? They're only one of the many reasons to buy a NexStar 9¼ GPS.

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We'll sell you the *right* telescope.

This month's hot new product line . . .

scopes and accessories from William Optics!

How much would you pay for a 2" star diagonal with a 97% reflectivity 1/10th wave accuracy enhanced aluminum mirror and a 1.25" eyepiece adapter? Some competitors charge as much as \$250 for such a combination. But the **William Optics 2" diagonal** shown above (our part #W2) is only \$99.95!

A 2" 99% reflectivity dielectric mirror Schmidt-Cassegrain diagonal, with a 1.25" adapter, costs a total of \$360 from a competitor. But the similarly-equipped 1/10th wave William Optics dielectric SCT diagonal to the right (our #W2DSC) is only \$230!

The 2" rotatable Schmidt-Cassegrain zero image shift Crayford-style manual focuser with

a 1.25" eyepiece adapter to the left (our #WSCF) is only \$149. As with all William Optics scopes and accessories, it offers exceptional value – fine optical performance and quality mechanics, at a price less than similar competitive products.

The **William Optics Megrez 80 II APO** fluorite triplet 80mm f/6.25 apochromatic refractor optical tube to the right has outstanding optics – truly excellent color correction, very high contrast, and tack-sharp images – for \$200 less than a competitive triplet apo that's similarly equipped. It's just another example of the exceptional value of the many unique William Optics products we stock.

Only \$995 for a 5" GPS-ready Celestron SCT!

The **Celestron NexStar 5i** is the *only* 5" telescope to have fully automatic GPS go-to available as an option. No other 5" scope has GPS! The NexStar 5i computer has a 45,000+ star and object database, adjustable height tripod, red dot finder, eyepiece – everything you need to start observing immediately! You get a free two-year warranty, too!

Multicoated optics are *standard equipment* with the Celestron NexStar 5i, not an option as with other scopes. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality?

Our 38 light pollution filters make bright skies dark.

If city lights wash out your view of the skies, get rid of the pollution with one of the 38 different light pollution reduction filters we stock.

We have two **Celestron** broadband filters. One is designed for 1.25" eyepieces; one for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, narrowband, and Oxygen III filters in 1.25" eyepiece

You can get your Meade extended service plan from us!

You can get a Meade Sky Assurance™ extended service plan from us even if you didn't buy your telescope from us!

Meade's new Sky Assurance™ service contracts extend Meade's standard telescope warranty from one year to a total of either three or five years. Sky Assurance™ service contracts cover all parts and labor costs due to defects in workmanship and materials (including normal wear and tear!) If the product can't be repaired, it will be replaced. There is no deductible for any covered repair.

You can enroll for extended service when you buy your telescope, or as late as one month before the expiration of the normal warranty period. In other words, you have eleven months from the date of purchase to decide whether you want to extend your warranty. Each extended service contract is effective from the date you buy your telescope.

Meade Sky Assurance™ also offers optional Advance Shipping Upgrades for the extended service contracts. If you choose this option,

Meade Sky Assurance Program

you'll be sent a Meade shipping container if you have a defective scope with instructions on how to pack and ship the scope to the Meade Service Center at no cost to you. All of the shipping costs are covered under this option.

Sky Assurance™ extended service contracts are renewable in three or five year increments for as long as you own your telescope. In addition, they are transferable to a new owner, should you sell your telescope while it is covered by a contract. Here's a sample of the 3-year Sky Assurance™ prices for some popular Meade scopes.

ETX-90, 3-year Sky Assurance \$64⁹⁹
LX90, 3-year Sky Assurance 144⁹⁹
8"/10" LX200, 3-year Sky Assurance 249⁹⁹
12"/14" LX200, 3-year Sky Assurance 324⁹⁹
16" LX200, 3-year Sky Assurance 999⁹⁹
 3-year Advance Shipping Upgrade 99⁹⁹

Full Meade Sky Assurance™ details are on our website, along with the 3-year and 5-year extended service pricing for all Meade scopes from under \$199.99 to over \$14,999.99.

The Celestron NexStar 8i

GPS-ready 8" go-to SCT costs only \$1379!

The \$1379 **Celestron NexStar 8i** costs hundreds less than other comparably-equipped 8" go-to scopes. You can start observing with it as soon as you take it out of the box. Its computer has a library of 45,000+ stars and objects it can find for you. It has a tripod, red dot finder, and eyepiece. Starbright multicoatings are standard equipment, not an optional extra. If you want GPS (an unavailable option on other scopes), it's only \$199. A two-year warranty is standard equipment. The NexStar 8i is enough scope to keep you observing for the rest of your life, at a price that leaves other scopes behind.

the NexStar 8i is shown with all standard accessories



\$1379

Tectron tools make reflector collimating easy!

Tectron collimating tools are a must for getting the most out of your Schmidt-Newtonian or Dobsonian. The \$43 Tectron Cheshire tool, left, will have

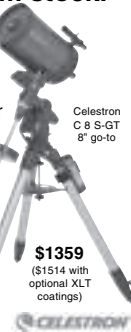
your reflector performing like a million bucks! Buy it alone or in a \$115 set that includes an autocollimator and sight tube. No self-respecting reflector should be without one.

Get a go-to now. We'll ship your Celestron from stock.

Celestron Advanced Series scopes put multicoated optics on an easy-to-use go-to mount. From a 5" SCT (with optics so good that NASA flies them on the Space Shuttle) to a 10" reflector, there's a Celestron go-to that's right for you and your budget. And state-of-the-art Starbright XLT multicoatings are available as an option on the bigger SCTs. Scopes include:

a 6" Newtonian reflector	\$799 ⁹⁹
an 8" Newtonian reflector	1019 ⁹⁹
a 6" achromatic refractor	1069 ⁹⁹
a 5" Schmidt-Cassegrain	1099 ⁹⁹
a 10" Newtonian reflector	1199 ⁹⁹
an 8" Schmidt-Cassegrain	1359 ⁹⁹
an 8" SCT with XLT coatings	1514 ⁹⁹
a 9 1/4" Schmidt-Cassegrain	1777 ⁹⁹
and a 9 1/4" SCT with XLT coatings	1999 ⁹⁹

Each Advanced Series go-to has an adjustable height tripod with 2" diameter steel legs instead of the lighter aluminum legs used on competitive scopes. Their computers find and track 45,000 stars and objects for you, compared to the competition's 30,000. The Celestrons have a *free* two-year warranty and ship from our stock. You don't have a long wait for another manufacturer to build and ship your scope to you.



\$1359

(S1514 with optional XLT coatings)

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Denkmeier Binoviewers are optimized for *your* scope.

Use both eyes to observe through a **Denkmeier Binoviewer**, and you can see up to 40% more detail than you can when looking through a single eyepiece. Your views of the planets, Moon, and deep space objects become almost three-dimensional.



Whether you have a refractor, reflector, or a Schmidt-Cassegrain, there is a Denkmeier Binoviewer with specialized optics that are optimized to give you peak visual performance with your scope's particular optical design. Prices start at \$599.

There's nothing mysterious about *this* Sphinx!

The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep sky objects.

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances more quickly.

The Star Book's 4MB flash ROM memory

can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book can be used as a stand-alone star atlas to let you learn the skies anywhere, anytime.

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in premium Vixen telescope/mount packages that range from a 3.1" f/5 refractor on a supremely portable tabletop go-to mount to big 8" reflectors and catadioptrics on full length field tripods.

You'll find full Vixen Sphinx details and prices on our www.astronomics.com website.



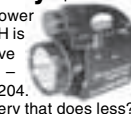
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FL80SWT-SXW 3.1" f/5 fluorite apo Vixen refractor on Sphinx go-to mount

Celestron rechargeable batteries start at only \$59⁹⁵!

Celestron Power Tank 7 and 17 amp-hour 12V DC batteries have the power you need to run your telescope all night long. They have two 12V DC cigarette lighter outputs; separate 3, 6, and 9V DC outputs for accessories; an emergency spotlight; built-in recharger; shoulder

strap; and more. The 7AH Power Tank is only \$59⁹⁵. The 17AH is \$109.95. A similar competitive 17AH dual output battery – with fewer features – costs \$204. Why pay far more for a battery that does less?



Takahashi premium apo optics are on sale!

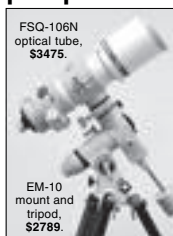
If there's anything better than the superb optical performance of a **Takahashi fluorite apochromatic** refractor, it's the speed at which you can get premium Takahashi optics from our stock.

Even better than the fast delivery are the special sale prices on Takahashi's best-selling optical tubes. You can save as much as \$2334 if you act now!

The 3.1" **FS-78** fluorite doublet optical tube is on sale for \$1195!

It's regularly \$1379, so you save \$184!

Takahashi's unique 90mm f/5.6 **Sky 90 II** is on sale for \$1849! Regularly \$2279, you save \$430! With dew shield retracted, this fluorite apo is less than 14" long! **Sky & Telescope** called it "an ideal travelscope for mobile observers, providing maximum performance at



\$3475

\$2789

minimum size."

The best-selling 4" **FS-102** fluorite doublet optical tube is on sale for **only \$1895!** Regularly \$2349, you save over \$450!

The 5" **FS-128** fluorite doublet optical tube is **only \$4495!** Regularly \$5249, you save over \$750!

Finally, the big 6" **FS-152** fluorite doublet optical tube is on sale for **only \$6995!** Regularly \$9329, you save \$2334!

We also stock the 22" long Takahashi **FSQ-106N 4-element f/5.4 dual fluorite 4" focuser** astrograph apo refractor OTA, shown on an optional mount to the left.

If you want a premium apo refractor at a money-saving sale price, and you want it without a lo-o-o-ng wait, the refractor you want is a Takahashi from **astronomics**.

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Does Mars have flowing water?

Dark streaks by the thousands run down the slopes of martian valleys and craters. They're dust avalanches, say most planetary scientists. But could any of these streaks be caused by groundwater seeps or springs? /// BY TÁHIRIH MOTAZEDIAN

Dark streaks on the slopes of martian hills, craters, and valleys have recently captivated scientists and space enthusiasts alike. These enigmatic features were first noted in Viking Orbiter photos decades ago, but the Mars Global Surveyor spacecraft's MOC imager photographed them with greater clarity starting in 1999. The MOC images have reinvigorated an old debate about whether Mars has water actively or intermittently flowing today on its surface.

The slope streaks are found on crater and valley walls. They widen downslope and weave around dunes, knobs, and crater rims. The streaks have no topographical relief, and they overlie existing surface features without perturbing them. MOC images taken months apart show new streaks are forming, making them some of the youngest surface features on Mars.

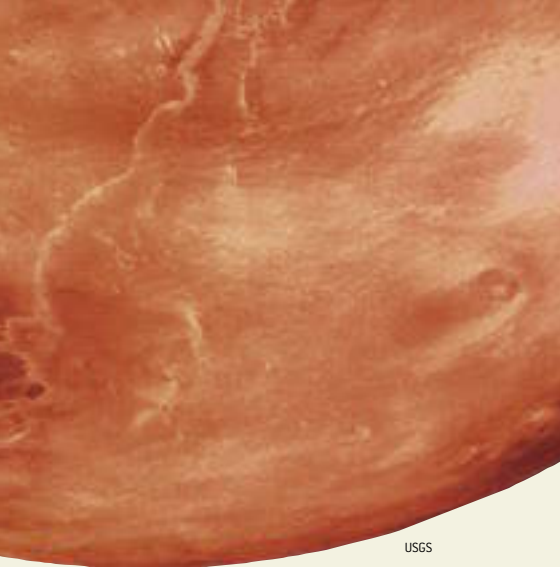
So what *are* these bizarre features? The answer most planetary scientists give is that the streaks are traces of dust avalanches. The answer is understandable; dust lies everywhere on Mars, settling continually from the air onto the ground, only to be picked up by the wind again and blown about. According to the conventional theory, some disturbance, high on a hillside where dust lies thick and the slope is steep, triggers a parcel of dust to begin sliding. Like snow, dust runs downhill, gathering more dust as it goes to make a dry avalanche. This removes a layer of surface dust, exposing the dark-colored martian basalt underneath.

But certain characteristics of dark slope-streaks are difficult to explain with the dust-avalanche model, leading some scientists to interpret these features as mineral stains left behind by liquid water

flow. Similar features are sometimes observed in deserts on Earth, where groundwater seeps or springs leave behind trails of "rock varnish." Present conditions on Mars are such that pure water would immediately freeze and evaporate. But scientists are constructing theoretical models that show how liquid brines heavily laden with dissolved minerals can exist now on the surface of Mars.

Clues in the dust

To understand the dark slope-streaks, it's worth exploring their characteristics, which may offer clues to their origin(s). Dark slope-streaks form in an equatorial band spanning from roughly 20° south latitude to 40° north. They concentrate in the volcanic regions of the Red Planet, being particularly dense in the vicinity of Olympus Mons. Towering 14 miles (22



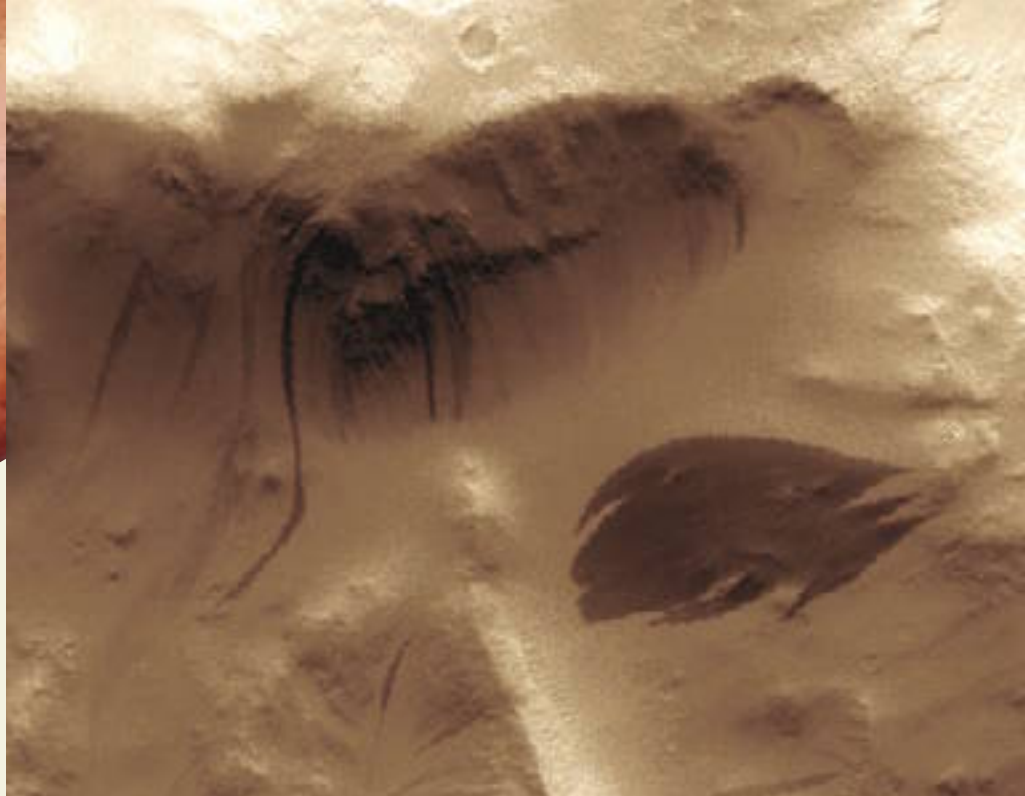
USGS

kilometers) above a base that reaches 370 miles (600 km) across, it's the largest volcano in the solar system.

The dark streaks always appear on slopes, mostly crater and valley walls, but also on the flanks of small hills. The slopes are generally modest; one research group at the California Institute of Technology found that slope angles range from 16° to 38°. Dark slope-streaks are typically about one hundred feet (a few tens of meters) wide and hundreds of yards (meters) long.

These streaks differ from other dark martian surface features in a number of ways. They possess sharp boundaries, as opposed to the hazy margins of dust-devil tracks and wind streaks. The slope streaks also show a more uniform tone across their expanse than do other dark surface features. Unlike dust-devil tracks, which wind erratically in shape and direction, dark slope-streaks in a given area exhibit common trends in shape, distribution, and direction. Unlike wind streaks, which form diffuse patterns on plains, slope streaks always occur on slopes, strongly suggesting they are driven by gravity.

Dark streaks begin narrow at their up-slope ends and widen downslope. They usually occur in clusters of parallel streaks, with most originating from a single rock layer. But while the top ends of the streaks generally line up, the bottom ends do not. Slope streaks often deflect around topographic obstacles, and many dark slope-streaks display strongly braided patterns. In certain locations, dark streaks overlie other surface features without disturbing them. Dark streaks never are seen to cause erosion. The slope streaks themselves have neither positive nor negative topographic



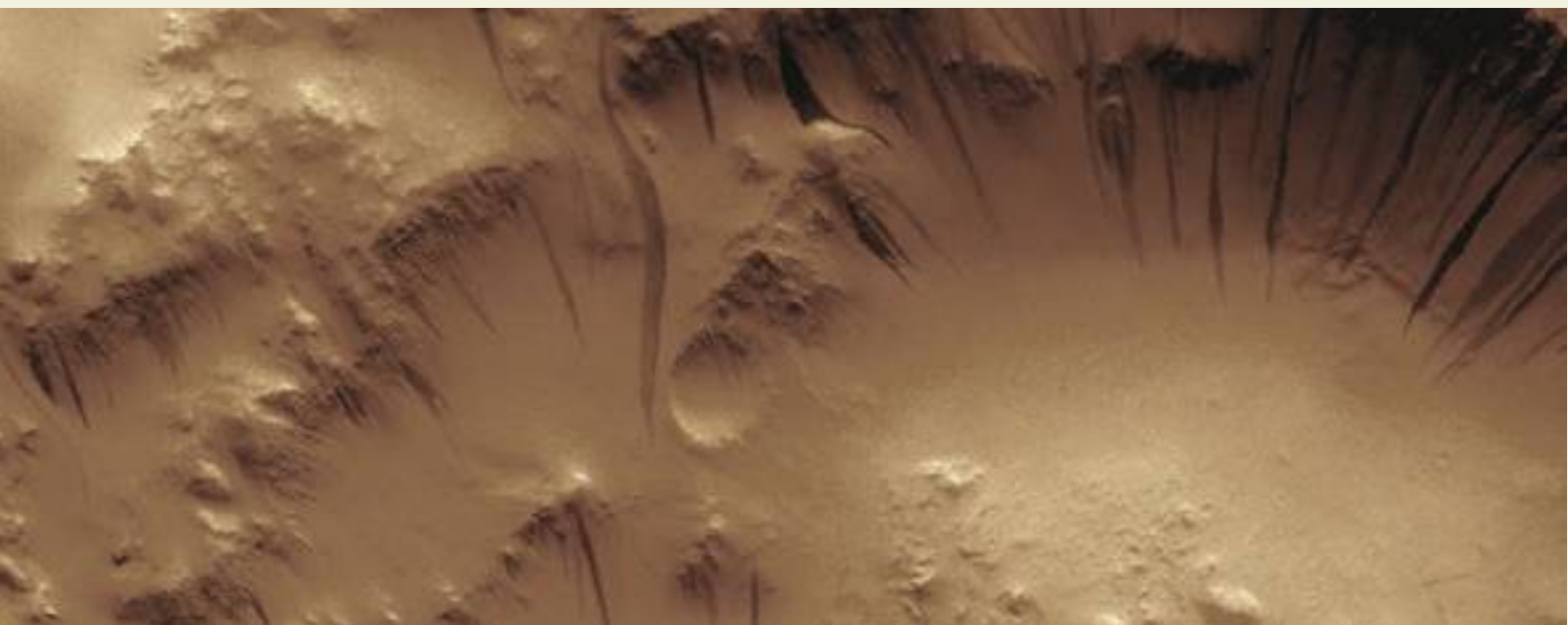
MORE THAN ONE MARS YEAR has passed since the upper image, E04-02259, was taken. Can you spot the new dark streaks in the bottom image, R06-00161, taken June 2003? ALL IMAGES: NASA/JPL/MSSS

relief; they appear simply as dark stains on the surface.

These features are among the youngest of all martian surface features — they are never cratered or overlain by other features such as sand dunes or by debris such as boulders or crater ejecta. Lighter-toned

streaks also are seen, with the darker streaks overlying the lighter ones.

Not only are the dark streaks geologically young, they are forming currently, as shown by MOC photographs of the same area taken at different times. While no one can say exactly how long it takes for slope



OBSTACLES DIVERT slope streaks easily, showing that they are not massive flows of material. Image E04-02259, taken May 28, 2001.



STREAKS ARE FLAT, displaying no topographic relief of their own. They look like ground stains. Image E04-02259, taken May 28, 2001.



STREAKS ENTERING a crater from higher up the slope rarely exit the crater downslope. Image E03-02458, taken April 28, 2001.



DARKER STREAKS commonly overlie or interrupt lighter-toned streaks; the latter are likely older. Image E02-02590, taken March 29, 2001.

streaks to form, newly formed streaks have appeared in MOC images taken just months apart. California Institute of Technology researchers estimate roughly seventy new slope streaks form each martian day! Regardless of the process(es) creating these features, the martian surface is currently undergoing active change.

How to make a slope streak

Planetary scientists know of a few ways to make dark slope-streaks. Gravity-driven

Táhirih Motazedian will earn her undergraduate degree in geophysics at the University of Oregon this spring, and she will be heading immediately after to NASA's Johnson Space Center for a research internship.

slides such as dust avalanches could strip away light-colored surface dust to reveal darker materials beneath. Yet while this process probably does account for certain types of dark streaks, other streak characteristics don't seem to fit this theory.

For one thing, if these features were all caused by gravity-driven slumping of dry materials on slopes, we would expect to see them all over the planet, in any region with similar topography and materials. Slope streaks, however, form only in specific regions on Mars.

Lack of erosion and topographic relief are other sticking points with the dust-avalanche theory. No deposits of dust or debris are visible near the streaks, whereas if a path were being carved through dusty

material on a slope, one would expect to see raised edges (levees) along the sides of the path. There would also be a pile-up of debris at the base of the slope.

Dark streaks overlie wind-generated (eolian) sand dunes and other surface features without erosion or disruption. This result is highly improbable if a mass of material was flowing over them. Slope streaks always originate with a sharp point-source and leave no apparent source scar. This is not typical of mass movements of material downslope, which tend to leave blunt, rounded head scarps. Some of the shapes of the dark streaks, particularly the braided patterns, suggest a highly fluid motion that's uncharacteristic of dry, gravity-driven mass movement.

Wind-driven processes do not appear to be a likely cause of slope streaks because of the streaks' sharply defined boundaries and uniform tone, and their consistent downslope attitude. The slope streaks bear distinctive shapes that are rarely (if ever) produced by wind streaks and dust-devil tracks. Moreover, the specific distribution of these streaks, running downslope in craters and valleys, is not consistent with formation by the broad, plains-sweeping action of the wind.

Going with the flow

Liquid flow is the most promising process for explaining the majority of dark slope-streaks. This theory has been presented also by Justin Ferris and others working at the University of Arizona. Geothermal activity surrounding Olympus Mons may be causing subsurface ice to melt or otherwise driving liquid water to the surface from aquifers. It is possible that subsurface water dissolves minerals in the aquifer to form a brine, which leaches metals from silicates in the rocks.

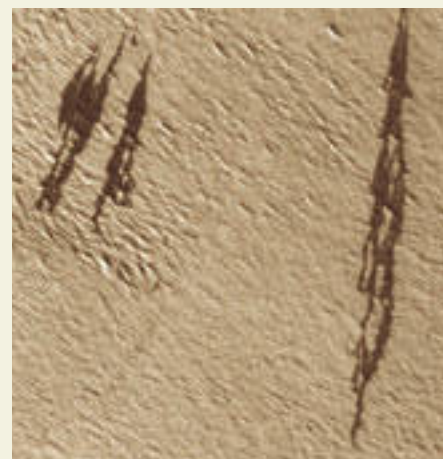
The salts in the brine solution would lower the freezing temperature as well as the vapor pressure, allowing the mineral-rich water to flow at the martian surface. As the brine flows downhill, it leaves behind a trail of rock varnish formed by dark minerals that precipitate from solution. The lighter-toned streaks are likely older streaks that have become coated with light-colored surface dust over time.

The dark slope-streaks originate from distinct layers, or geologic horizons, below the martian surface, where the water/ice table meets crater and valley walls. The point-source origin of the dark streaks seems to indicate the piping of groundwater, as opposed to an aquifer-wide, broad flow. The braiding of the dark streaks indicates dynamic fluid motion. The fact that slope streaks neither build up topographic debris nor erode materials is consistent with small volumes of liquid trickling gently down a slope. The sharply defined ends of the dark streaks imply that the flows end where their liquid source is exhausted, having been consumed in coating surface dust and soaking back into the ground.

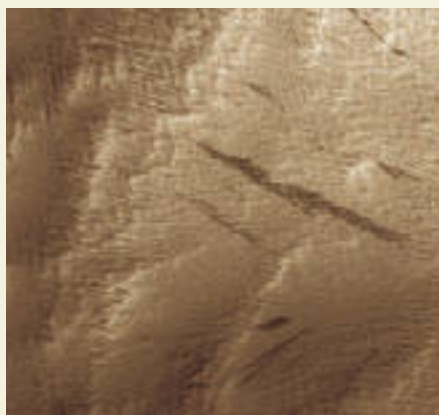
While the origin of dark slope-streaks isn't yet definitively known, it is very exciting to see the presence of currently active surface processes altering the face of Mars. The fact that there are daily changes invali-



DIFFERENT LENGTHS characterize dark slope-streaks on Mars. While streaks generally begin at one elevation on a wall, the run-out distances vary based on the slope's angle. Image E03-02458, taken April 28, 2001.



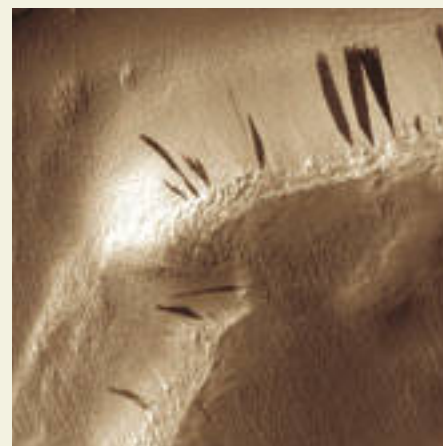
BRAIDED PATTERNS that look like shadows appear in some slope streaks. These patterns resemble shallow stream beds found at many locations on Earth. Image E02-00308, taken March 4, 2001.



NEW STREAKS appear all the time; about six months separate these two images. *Left*, image M21-01403, taken November 22, 2000; *Right*, image E04-01210, taken May 17, 2001.



DOZENS OF NEW STREAKS appear on the planet every martian day, according to researchers. *Left*, image SP2-37303, taken June 18, 1998; *Right*, image E02-02379, taken March 26, 2001.



dates the old idea that Mars is a dead planet. If these slope streaks in fact are being caused by the flow of liquid water, a flood of new scientific research and exploration will ensue, and fresh motivation and

impetus will be instilled in the field of planetary space exploration. ■



To learn more about our changing view of Mars, visit www.astronomy.com/toc

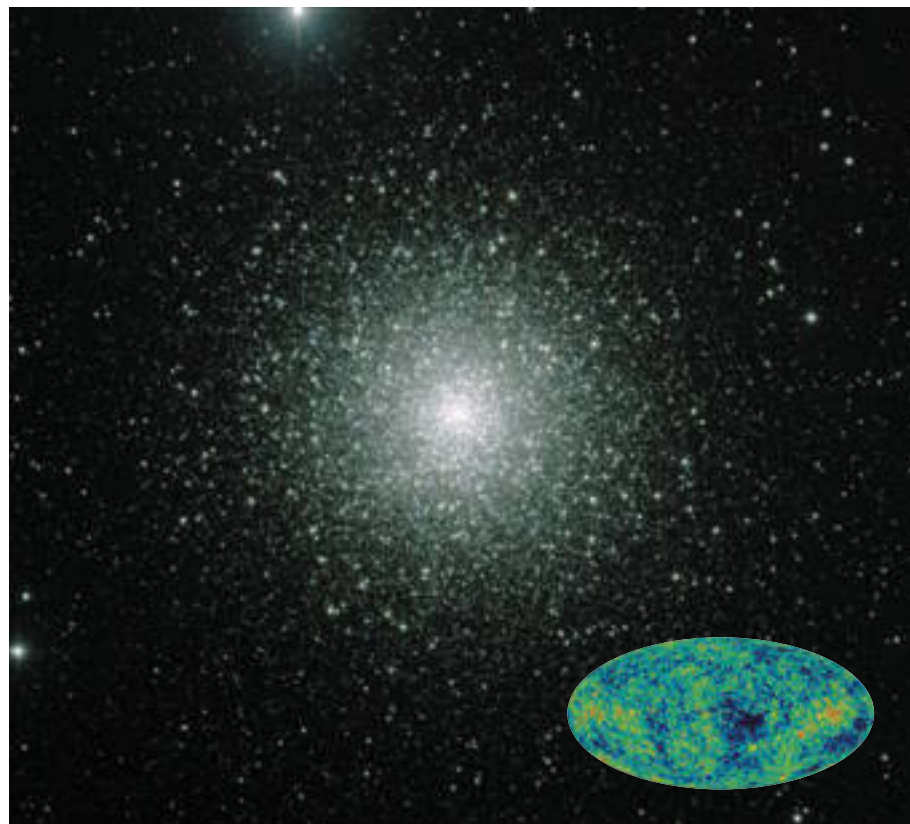
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Stars older than the universe, reading star temperatures, and launch tips for Moon trips

COSMIC CONUNDRUM

I've heard that astronomers have found stars up to 19 billion years old. It seems to be accepted now that the universe is 13.5 billion years old, and I missed how that number was determined. Can we have a Big Bang from stars that were burning for 5 billion years before the expansion happened?

— ROCK WILSON



AGES OF STARS in globular clusters like M15 (background) seem to conflict with the age of the universe determined by other means. WMAP's study of temperature fluctuations in the early universe (inset) has helped resolve the apparent discrepancy. NOAO/AURA/NSF; NASA/WMAP

Most estimates of the age of the universe are based on the observation that distant galaxies are moving away from us at very high velocities, indicating that the universe is expanding. This means the galaxies must have been closer together in the past, and all matter in the universe once must have

been concentrated within a very tiny volume. This has given rise to the notion that the universe started with a “Big Bang,” expanding from an initial state of extremely high density. By measuring the expansion velocity and distances to galaxies, one can, in principle, calculate how long ago the

Big Bang occurred. But it's very difficult to measure distances to galaxies accurately, and the expansion rate may not have been constant during the lifetime of the universe.

The recent estimate of 13.7 ± 0.2 billion years for the age of the universe comes from measurements of a quite different nature carried out with the Wilkinson Microwave Anisotropy Probe (WMAP). This satellite measured tiny fluctuations in the so-called cosmic microwave background, which basically consists of radiation that was released about 300,000 years after the Big Bang and has been propagating freely throughout the universe ever since. Accurate measurements of these fluctuations have allowed astronomers to determine not only the expansion rate, but also the acceleration, and thereby tell how much time has elapsed since the radiation was released.

Determining the ages of the oldest stars usually relies on comparisons of observed colors and luminosities for stars in globular clusters with predictions made by stellar models. Here, the problem is that these models remain far from perfect, and a globular cluster that is 15 billion years old does not look very different from one that is, say, only 10 billion years old. However, our understanding of the various ingredients that go into stellar models continues to improve, and the discrepancy between globular cluster ages and the WMAP age of the universe is rapidly decreasing. In fact, many recent studies have found most globular clusters to be slightly younger than 13.7 billion years.

In summary, the main reason the oldest stars sometimes appear to be older than the universe itself is that both ages have considerable uncertainties associated with them. Thanks to the hard work of many researchers, those uncertainties continue to decrease. — **SOEREN LARSEN**, EUROPEAN SOUTHERN OBSERVATORY

STELLAR FINGERPRINTS

How do I find the temperatures of the stars that make up the Big Dipper?

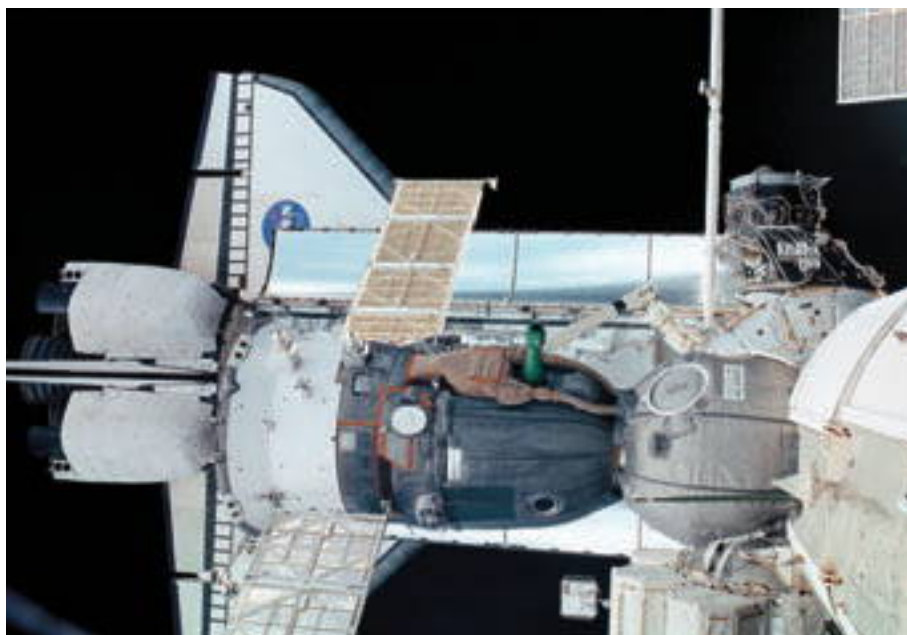
— M. J. MOORER

Stars radiate their energy much the same way a piece of hot metal does. Note that astronomers normally use a temperature scale denoted “K” for Kelvin, where 2,000 K corresponds to about 3,000° F, and 10,000 K is roughly 17,500° F. When the temperature of a piece of metal (or a star) reaches about 2,000 K, it starts glowing a deep red. As the temperature increases, it glows orange, then yellow, and at temperatures of 10,000 K or more, blue-white.

So astronomers can get a good idea about the surface temperature of a star by simply measuring its color. Most of the stars in the Big Dipper are blue-white, indicating surface temperatures around 10,000 K, or about twice as hot as the Sun (5,500 K). One exception is the star Dubhe, the first star at the lip of the “bowl,” which is much redder (and so cooler) than the other stars. This star has a temperature of around 4,700 K, slightly cooler than the Sun.

For more accurate measurements of stellar temperatures, astronomers use a powerful technique known as “spectroscopy.” Basically, the light from the star is sent through a diffraction grating, which splits the light into a rainbow of colors called a spectrum. Stellar spectra contain a number of dark lines that always are located at the same position (wavelength) in the spectrum. These spectral lines are a kind of “fingerprint,” each corresponding to a specific element present in the star.

During the late 19th and early 20th centuries, astronomers realized that most stellar spectra can be organized into a few well-defined groups based on the appearance of the various lines. The main spectral types are denoted by the letters O, B, A, F, G, K, and M, with temperature increasing along the sequence. O-type stars are the hottest, with surface temperatures of 50,000 K or more, while M stars are the coolest, with temperatures of about 2,000 K. Recently, even cooler stars have been



CREW MEMBERS photographed space shuttle Atlantis (background) and a Soyuz vehicle docked to the International Space Station in April 2002. The station's high orbital angle makes it less desirable as a point of departure for missions to the Moon and planets. NASA

discovered, prompting the introduction of two new spectral types, L and T. Most of the stars in the Big Dipper are A-type stars, while the Sun is a G-type star. — **SOEREN LARSEN**, EUROPEAN SOUTHERN OBSERVATORY

ROCKET SCIENCE

I've heard that shuttles have to work hard to get to the International Space Station (ISS) because of its 51.6° orbit, and that missions to the Moon and planets launched from ISS would have to work harder too. Why?

— **MICHAEL FLEISCHER**, TENAFLY, NEW JERSEY

Rockets leaving Earth get an extra “kick” when launched eastward because of Earth's rotation. A shuttle launched due east from Kennedy Space Center (KSC) in Florida ends up in an orbit inclined 28.5° to the equator because that's the latitude of the launch site. It gets a free speed boost of 1,300 feet per second, which lets the vehicle carry the maximum amount of payload into space. That's why 28.5° orbits are so special, at least from NASA's perspective.

Suppose we have two spaceships at the same altitude, one in an orbit inclined

51.6° (like ISS) and another in an orbit inclined 28.5°. Also suppose that it is late March of 1969, a time when the Moon's orbit happened to be inclined 28.5° to Earth's equator.

The spaceship headed to the Moon from the highly inclined orbit must move into the Moon's orbital plane before starting its journey. Making this adjustment requires a substantial change in velocity — about 1.9 miles per second — which consumes a lot of fuel.

Contrast this to the spaceship starting from the 28.5° orbit. Because it's already in the correct plane, this spacecraft can expend all its fuel carrying cargo to the Moon. The same principle applies to trips to the planets, which all lie near the plane of the ecliptic.

So a Saturn V launched due east from KSC back in 1969 could carry the maximum amount of payload to the Moon and conserve fuel. Because the Moon's orbital inclination changes over a cycle that lasts 18.6 years, this means the same fortuitous configuration occurs again in mid-June of 2006 and late January of 2025. Travelers take note! — **BILL COOKE**, NASA/MARSHALL SPACE FLIGHT CENTER

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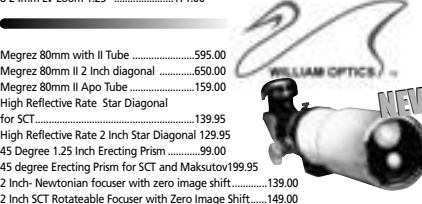


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SOLAR SYSTEM OBSERVING

For the first time in 122 years, Earth's next-door neighbor will cross the Sun's face. Here's all you need to know to view this exceptional event. /// BY MICHAEL E. BAKICH

Viewing Venus in transit

In my short span of years on Earth (by astronomical reckoning, anyway), I have witnessed several “once-in-a-lifetime” events: bright comets like Ikeya-Seki (1965), Hyakutake (1996), and Hale-Bopp (1997); a nearby exploding star (Supernova 1987A in the Large Magellanic Cloud); and a comet crashing into a planet (Shoemaker-

Levy 9's 1994 impact of Jupiter). Each of these marvels, however, caught us by surprise. Now a predicted event is about to happen that no human alive today has ever seen. On June 8, 2004, two of the sky's most brilliant objects will meet as Venus transits the face of the Sun.

Weather permitting, the best spots to observe the transit will be Europe, Africa, and Asia — from where the entire event will be visible. The beginning of the transit will be seen from Japan, the Philippines, and Australia, but the Sun will set before the event ends. Observers in eastern North America, the Caribbean, and most of South America will see only the end of the event after the Sun rises.

Understanding transits

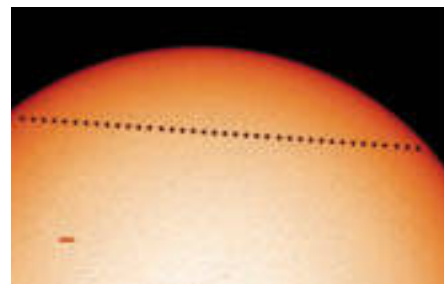
A transit occurs when one celestial body crosses in front of a bigger one. Planetary transits result when either Mercury or Venus passes across the face of the Sun as seen from Earth. This can happen only when one of these planets reaches inferior conjunction (lying between Earth and the Sun). However, for the same reason we don't see eclipses every two weeks, transits do not occur at each inferior conjunction. Because the orbits of both Mercury and Venus tilt with respect to the ecliptic, the plane of Earth's orbit in space, the planets typically pass either above or below the

Sun at inferior conjunction. (Mercury's orbit tilts 7° to the ecliptic, and Venus's orbit tilts 3.4°.) If inferior conjunction happens within a day or so of the planet crossing the ecliptic, a transit will result. Transits of Mercury are uncommon — on average, thirteen occur each century. Transits of Venus are rare.

All transits of Venus fall within several days of either June 8 or December 9, the two dates when the orbit of Venus crosses the ecliptic. The two points of intersection, known as nodes, lie approximately 77° and 257° of longitude from the Sun. If Venus passes through inferior conjunction when its longitude is near 77° (around June 8) or 257° (around December 9), a transit occurs. Transits of Venus always occur in pairs eight years apart. A recurring pattern of either 105.5 or 121.5 years between the last transit of one pair and the first transit of the next pair also exists.

The four transits of Venus that occurred in the 18th and 19th centuries rank among the most eagerly anticipated events in the history of observational astronomy. Observers deployed an army of telescopes to chart precisely the passage of Venus across the Sun. (See “Chasing the shadow of Venus” on page 32.) Unfortunately, the results proved less than satisfying.

The main problem that arose was reconciling the time of the entrance of Venus onto the disk of the Sun (and at the end of the transit, its exit from the disk) from one observer to the next. You might assume



THE SOHO SPACECRAFT CAPTURED the entire 2003 transit of Mercury in a series of exposures. At greatest transit, Mercury lay slightly farther from the center of the Sun's disk than Venus will during the June 8 transit. NASA/SOHO

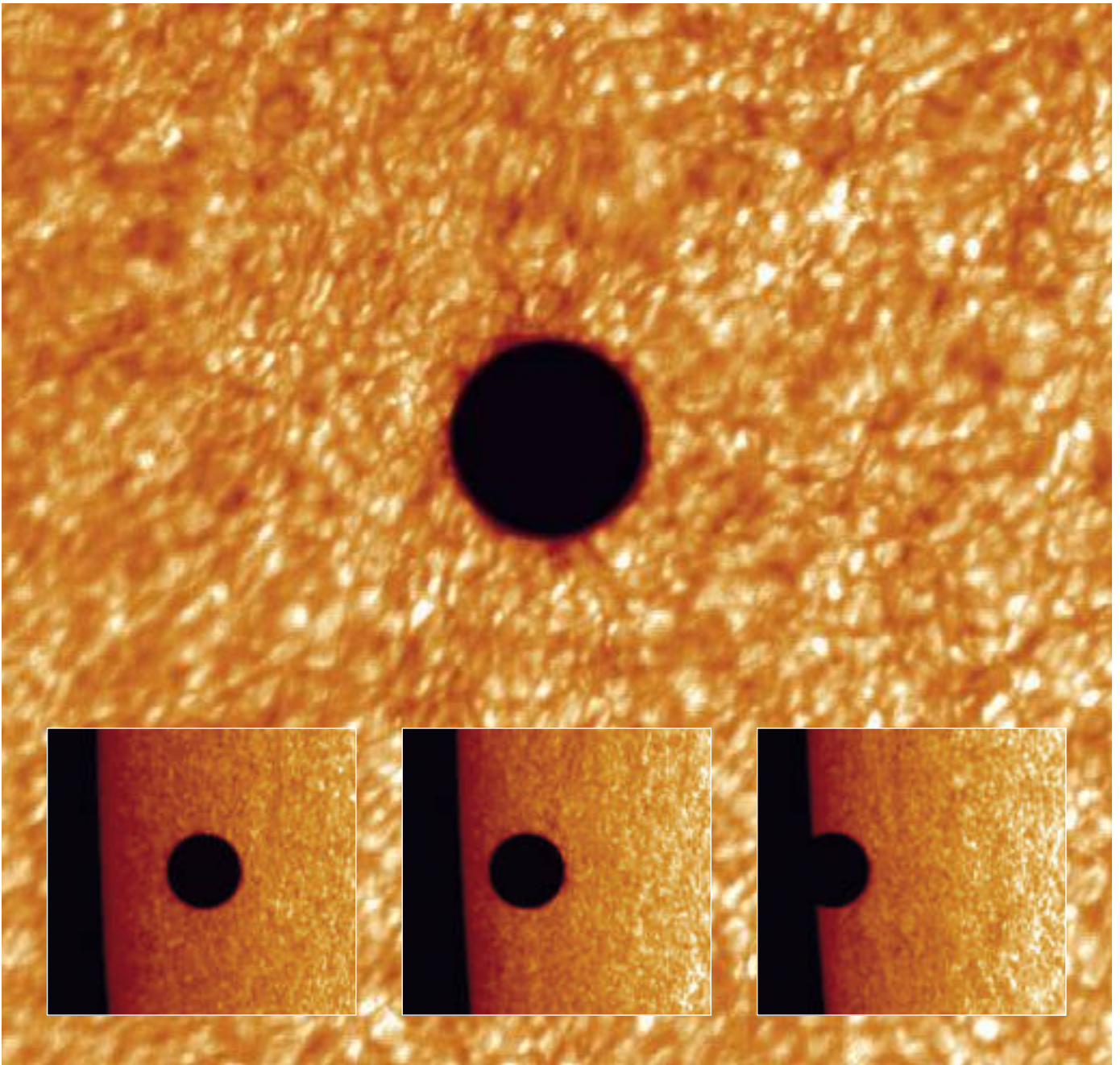
that because Venus appears as a black circle and the Sun's disk is so bright, the instant when the entire sphere of Venus crosses onto the Sun's face would be easy to determine. Under real conditions, however, at the moment Venus is about to enter fully onto the Sun's face, the planet's disk almost seems to attach itself to the limb of the Sun, much like a water droplet emerging from a faucet. Then, all at once, the connection breaks and Venus stands some distance inside the solar limb. The same effect occurs when Venus exits the bright disk of the Sun. Observers christened this phenomenon the “Black Drop” or the “Black Ligament.” Because of the black-drop effect, the timing observations of skilled observers with decades of experience showed significant differences.

Transit 2004

Unless human life spans get a big boost in the next century, those of you reading this will have at most two opportunities to view a Venus transit: on June 8, 2004, and June 6, 2012. Following these events, another transit of Venus will not occur until December 11, 2117.

As in real estate, three things will matter most for viewing the 2004 transit:

Michael E. Bakich is an associate editor of *Astronomy*.



TRANSITS ACROSS THE SUN are rare events. Those of Mercury, like the one from 2003 seen here, occur on average 13 times a century. But June's transit of Venus will be the first since 1882. ROYAL SWEDISH ACADEMY OF SCIENCES

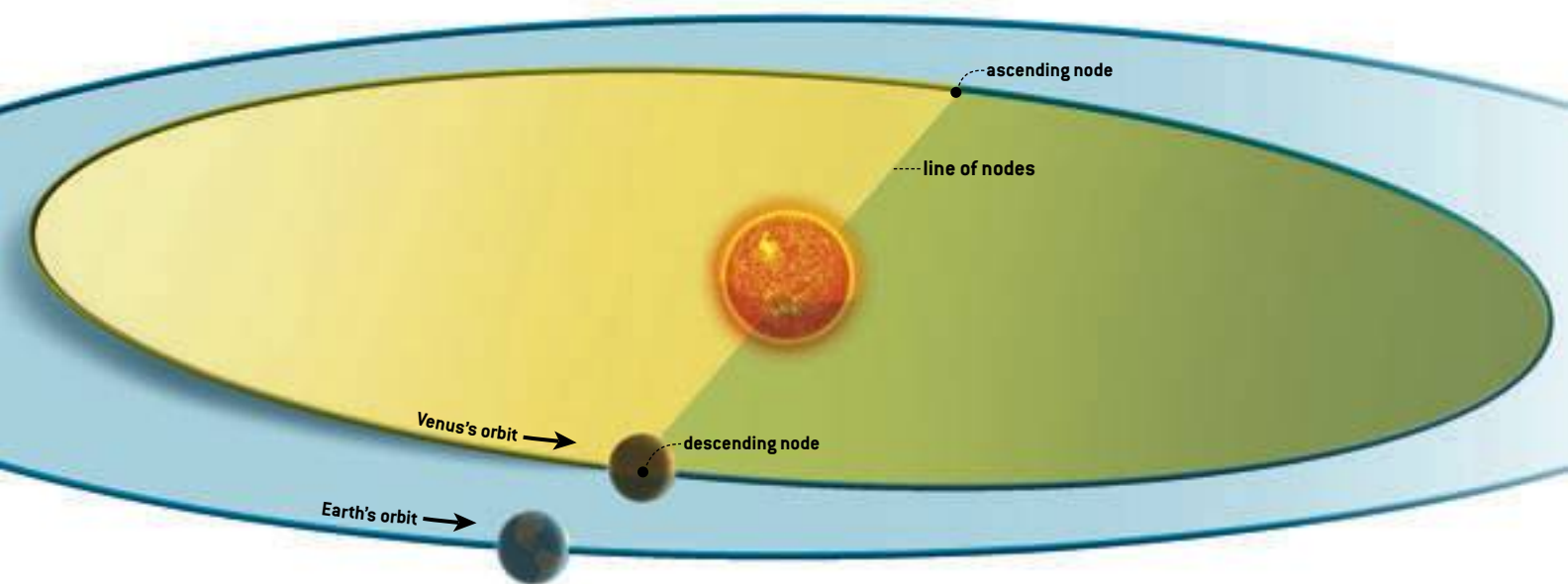
/// TRANSITS FROM OTHER PLANETS?

For a transit to be observable from any location, the transiting planet must be between the observer and the Sun. On May 11, 1984, Earth transited the disk of the Sun for a theoretical observer on Mars. Earth took about 8 hours to traverse the face of the Sun. The Moon began its transit about 6 hours later, so for two hours, both Earth and the Moon would have been seen as black dots crossing the Sun.

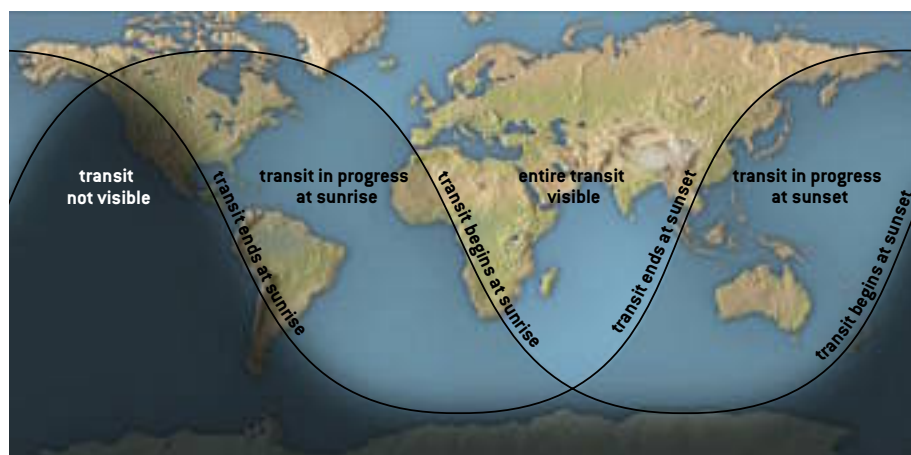
/// MAJOR TRANSIT EVENTS

Mid-transit is the time when Venus lies closest to the Sun's center. The times given in this table are for a hypothetical observer at Earth's center. The actual contact times for any location on Earth's surface can differ by up to 7 minutes before or after these times. The position angle refers to the direction of Venus with respect to the center of the Sun's disk, measured counterclockwise from the celestial north point on the Sun.

EVENT	UNIVERSAL TIME	POSITION ANGLE
First contact	5h13m29s	116°
Second contact	5h32m55s	119°
Mid-transit	8h19m44s	166°
Third contact	11h06m33s	213°
Fourth contact	11h25m59s	216°



TRANSITS OF VENUS can occur only when Venus crosses one of the nodes of its orbit at the same time it reaches inferior conjunction. ASTRONOMY: ROEN KELLY



PEOPLE IN EASTERN NORTH AND SOUTH AMERICA will see the end of the transit just after sunrise on June 8. The best locations for observing the Venus transit will be in Europe, Africa, and Asia. The duration of the transit for observers in the United States is shown in the lower right diagram. ASTRONOMY: ROEN KELLY

/// TRANSIT – AN ALTERNATE DEFINITION

If you read enough astronomical literature or listen to enough observers, eventually you'll encounter the word *transit* used in a different context. When any celestial body crosses an observer's meridian (the line joining the north and south horizon points and passing through the zenith), that event is called a transit.

Used in this way, two types of transits are possible — upper transit and lower transit. At upper transit (usually the "upper" is dropped), a celestial body lies at its highest point in the sky. For example, when the Sun reaches upper transit for an observer in the northern temperate latitudes, it appears highest in the sky and lies due south. At that particular location, it is local noon. One-half Earth rotation later, the Sun lies at its lowest possible point — lower

transit — and it is local midnight at the observer's location. Amateur astronomers usually want to observe objects around the time they transit because that's when they are highest in the sky and can be viewed through the least amount of Earth's atmosphere.

For the majority of celestial objects (the Sun, Moon, planets, and most stars) lower transit occurs when the object lies below the horizon. Certain lower transits, however, are visible. Depending on your location, some stars around the celestial poles never set. These are called circumpolar stars. When a circumpolar star lies directly beneath the celestial pole, it is both at lower transit and also above the horizon. If it's night and clear when this occurs, that star will be visible.

/// OUT OF AFRICA

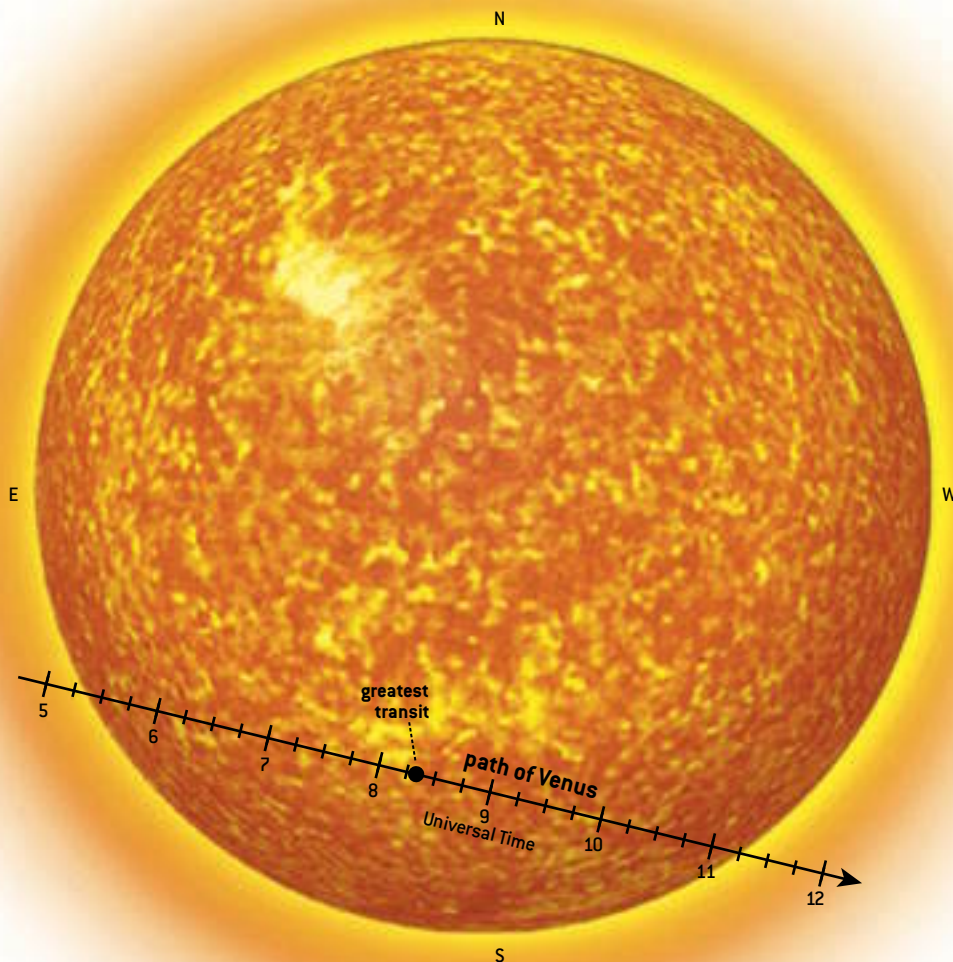
Astronomy magazine plans two tours to Africa to view the 2004 Venus transit. Editor Dave Eicher will lead one group to the northern part of the continent, viewing the transit from Luxor, Egypt. Seen from that spot, the transit will last 6 hours and 5 minutes with the Sun positioned 75° above the horizon at mid-transit.

Associate editor Michael Bakich will head the group at the other end of the continent, which will observe from the Entabeni Game Reserve in South Africa. Viewed from there, the transit will last 6 hours and 11 minutes with the Sun reaching a maximum altitude of 43°. For more details on these trips and others, see astronomy.com/content/static/trips

location, location, and location. In the United States, no one will see Venus transit the Sun for more than two-and-a-half hours. Observers with clear skies in eastern New York and New England will see at least 120 minutes of the transit. That number drops to 60 minutes for observers on a line curving from north-central Minnesota to northeastern Florida. And none of the transit will be visible from the Mountain states or the Pacific Coast. Even from the favored Northeast, the Sun will have climbed only about 24° above the horizon by transit's end. By contrast, observers in Europe, Asia, and Africa can follow the entire transit, which will last more than six hours.

During the transit, four events — called contacts and analogous to the four contacts in a total solar eclipse — define the beginning and end. “First contact” occurs when the dark edge of Venus’s disk first touches the bright solar background. “Second contact” marks the instant when the Sun first completely surrounds the entire disk of Venus. Note that this occurs after the black-drop effect has ended. “Third contact” occurs when the edge of Venus again touches the Sun’s edge, and “fourth contact” is defined as the instant when the disk of Venus can no longer be seen silhouetted against the Sun.

Venus’s disk will have a diameter $\frac{1}{2}$ (3.125 percent) of the Sun’s, so astute observers should be able to detect the transit with their properly protected naked eyes. That’s a key point — because the Sun is



THE PATH OF VENUS on June 8 takes it across the Sun's southern hemisphere. Times are given in Universal Time; subtract 4 hours to convert to Eastern Daylight Time. ASTRONOMY: ROEN KELLY

involved, make sure to safeguard your eyes when viewing the transit. Never look directly at the Sun without using a proper solar filter. Retinal damage can occur in just a few seconds when looking with the naked eye, and in a fraction of a second with binoculars or a telescope. Use a #14 arc-

welder's glass or a Mylar or metal-on-glass filter specifically designed for solar viewing.

An interesting observation can be made through a telescope equipped with a hydrogen-alpha filter. If a solar prominence is fortuitously placed, you'll be able to see Venus silhouetted against it before the actual transit begins or after the transit ends. Will the black-drop effect manifest itself in the subdued hydrogen-alpha light? Nobody knows for sure because such an observation has never been made.

Observing the June 8 transit of Venus requires only a good location, clear skies, a solar filter, and — if you're observing from an area where the Sun will be high in the sky — lots of sunscreen. Use a telescope if you want to try your hand at timing the four contacts. Send or e-mail photographs or CCD images of individual transit shots or interesting montages to our “Reader gallery.” The address is listed on page 103. We'll publish the best images in an upcoming issue. Good luck, and watch out for the Black Drop. ■

/// WHAT HAVE TRANSITS TAUGHT US?

Transits of Venus have allowed astronomers of the past to learn two important facts about our “twin” world. First, they discovered that Venus has no moon. Some have conjectured that if Venus had a moon in a close orbit, the brilliancy of the planet would overwhelm the moon's light, and such a moon would remain undiscovered. It was, therefore, a matter of some importance for astronomers to examine Venus's immediate vicinity carefully during transits. If a satellite of any appreciable dimensions had existed, it would have been detected against the brightly lit background of the Sun. Another fact first gleaned about Venus as a result of a transit was the existence of its atmosphere. This was discovered by Mikhail Vasilyevich Lomonosov during the transit of

1761. If Venus had no atmosphere, nothing would be seen just before the start of its trek across the solar disk, and the planet would relapse into invisibility immediately after the transit. Lomonosov's observations proved otherwise, however. As Venus gradually moved off the Sun, the circular edge of the planet extending out into the darkness was seen to be bounded by an arc of light. Some observers with large telescopes under extremely favorable conditions were able to follow the planet until it moved entirely away from the brilliant solar background. At that point, the globe of Venus, although itself invisible, was marked distinctly by the circle of light surrounding it. The only explanation possible is that Venus is surrounded by an atmosphere.



To learn more about viewing the 2004 transit, visit www.astronomy.com/toc



ASTROPHOTOGRAPHY

Using today's CCD technology, amateur astronomers can do a lot more than just look through an eyepiece. /// BY JACK B. NEWTON

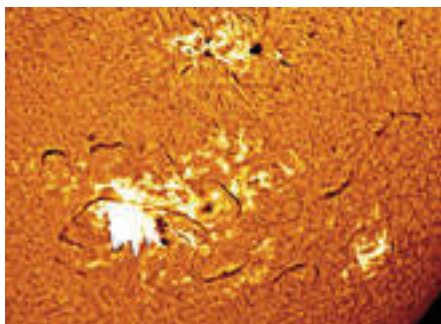
Amateur CCD discoveries

Ah, the joys of discovery! I remember the feeling of pride I experienced as a 12-year-old who, using a 2-inch refractor from a church rooftop, had *independently discovered* the ring around Saturn. The world was my oyster, and the entire universe beckoned each evening in the dark, prairie skies overhead. Fast-forward almost fifty years, and I

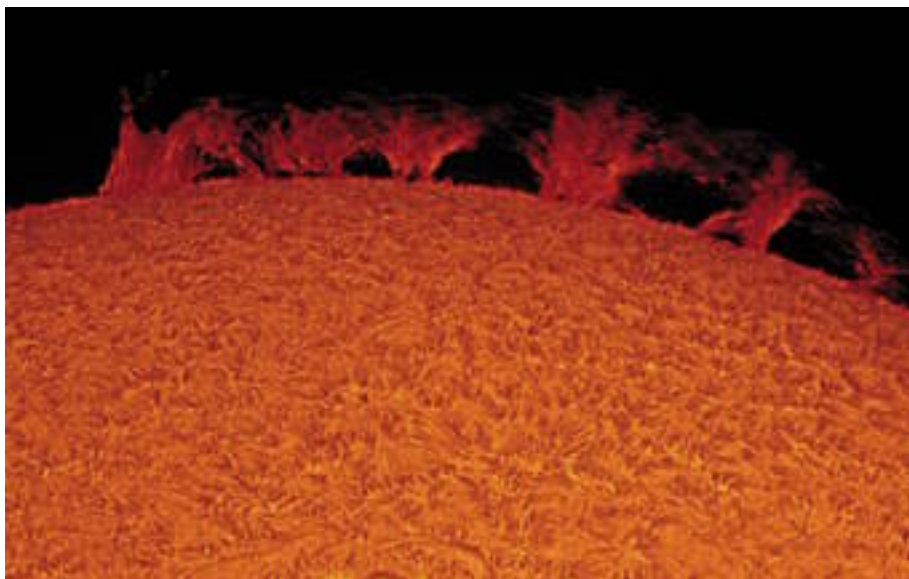
still enjoy the thrill that comes with unfolding the mysteries of the night sky.

The first CCD (charge-coupled device) cameras were introduced to amateur astronomers around 1991. Santa Barbara Instrument Group's ST-6 and Spectra

Source's LYNXX-PC and HPC-1 models emerged as powerful new tools then. These CCD cameras revolutionized the ability of amateur astronomers to make discoveries using relatively inexpensive — but cutting-edge — devices.



THE SUN is in a constant state of change, and although Earth-based telescopes track its activity on a daily basis, opportunities for discoveries by amateurs exist any time other sites are cloudy or, being in other time zones, lie in darkness. *Left:* On October 29, 2003, the author recorded a large flare in the Sun's lower center, which overexposed and bloomed the area in brilliant white. *Below:* This shot of the Sun, taken by the author on January 9, 2004, reveals a tremendous outburst of prominence activity. JACK B. NEWTON



New limits

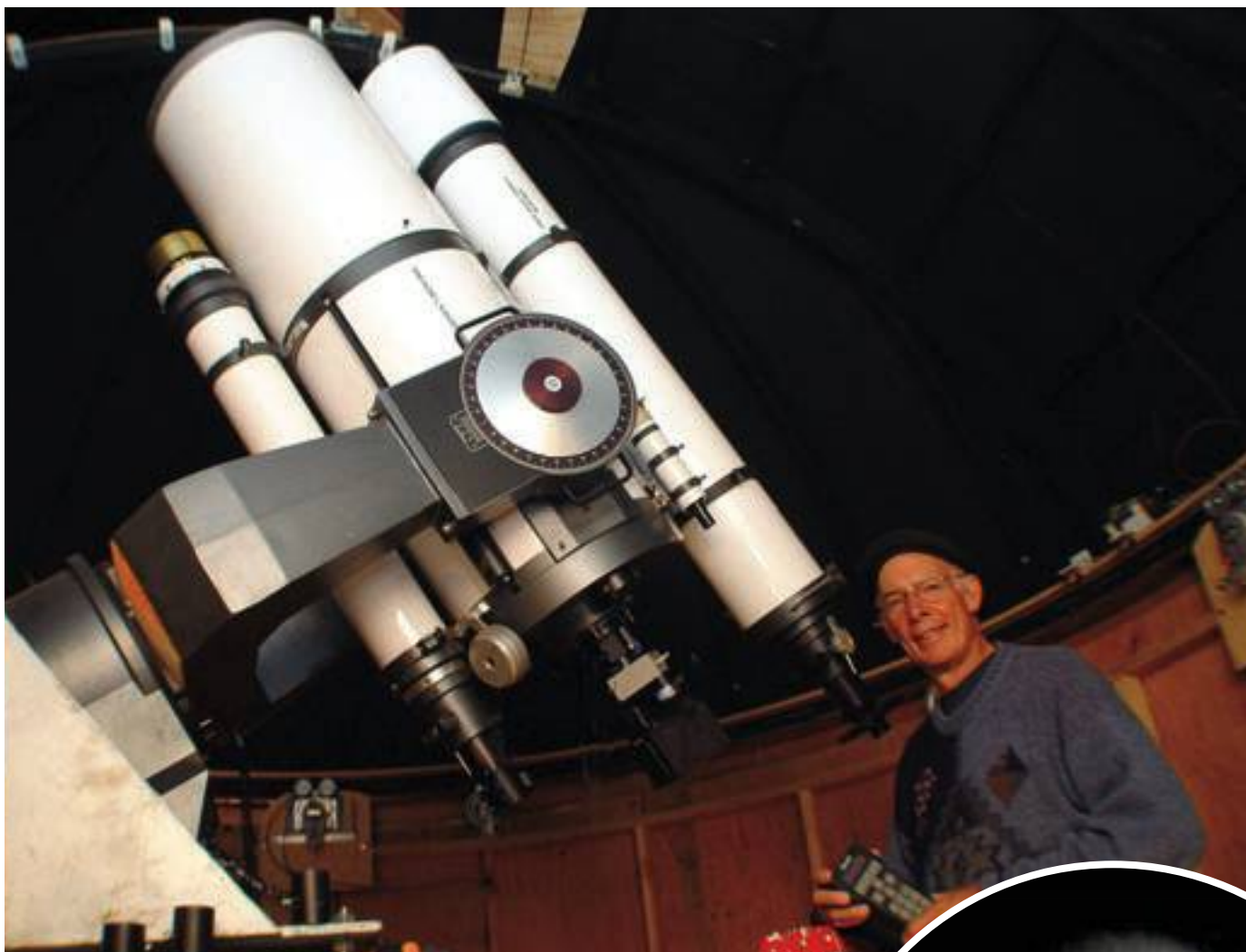
What has the advent of the CCD camera meant to astronomical discovery? Where amateur astronomers are concerned, the availability of modestly priced cameras brings the distant universe into our homes and domes. We wander at will among distant galaxies, and we have even more time to relish the destination. Using a 7-inch Meade apochromatic refractor at f/9, and stacking only six 10-minute exposures, I can record objects on my Finger Lakes Instrumentation Dream Machine CCD camera fainter than those on the Palomar Sky Survey. When I turn my 16-inch Meade LX200 Schmidt-Cassegrain telescope loose, I can image galaxies that most likely have never been seen from Earth.

If you're concerned your observing site won't allow such feats, think again. CCD cameras are so sensitive that dense filters, which essentially eliminate light pollution, can be used. A deep-red #92 Wratten filter — or better yet, a hydrogen-alpha filter — will all but eliminate light pollution.

The role of software

Myriad software programs have been created to support both the operation of CCD cameras and the processing of images taken with them. At the forefront of this digital domain are programs such as *MaxIm DL*. *MaxIm DL* interfaces with numerous brands of CCD cameras and autoguiders. It provides total image acquisition, manipulation, and telescope control. An analysis program called *MaxPoint* uses a CCD camera to map a telescope's pointing errors and create a model that corrects them.

A program called *PinPoint* works with sky-plotting software, such as *Desktop Universe* or *TheSky*, to move your telescope to an object and command your camera to take a short exposure. *PinPoint*



JACK NEWTON is happiest when imaging in his 16-foot-diameter rooftop observatory at Arizona Sky Village in Portal. His primary telescope is a 16-inch Meade LX200 Schmidt-Cassegrain. He frequently uses 7-inch and 5-inch Meade apochromatic refractors piggybacked on the 16-inch scope. In this picture, the 5-inch is shown with a Coronado 90mm hydrogen-alpha filter attached. ALICE NEWTON

cross-checks the stars in your image against a stored database to identify exactly where the telescope is pointing. It then moves the telescope and accurately centers the object. The exact positions of the stars in a CCD image, therefore, can be measured in seconds. *PinPoint* is of particular value for robotic (remote-controlled) telescopes because it overcomes the difficulty associated with using a mount that is not perfectly aligned with the celestial pole.

Martian discoveries

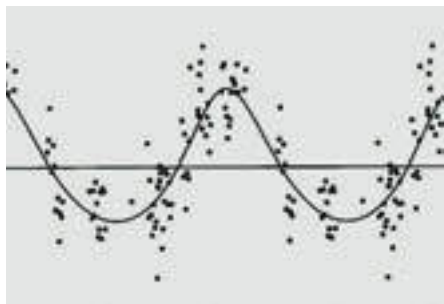
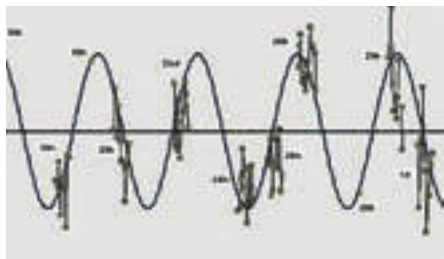
CCD imaging has been treating us to tantalizing snippets of Mars for some time now, mainly thanks to the phenomenal work of Donald C. Parker of Coral Gables, Florida. Parker's nearly continuous imaging of Mars during the last thirteen years has resulted in his being dubbed the "Mars

Weatherman." Using a LYNXX-PC CCD camera, Parker has gathered thousands of images of the Red Planet and has become familiar with the weather systems crossing Mars. In the process of repeatedly imaging the planet and painstakingly analyzing data gathered in his observing sessions, Parker has made a number of fascinating discoveries.

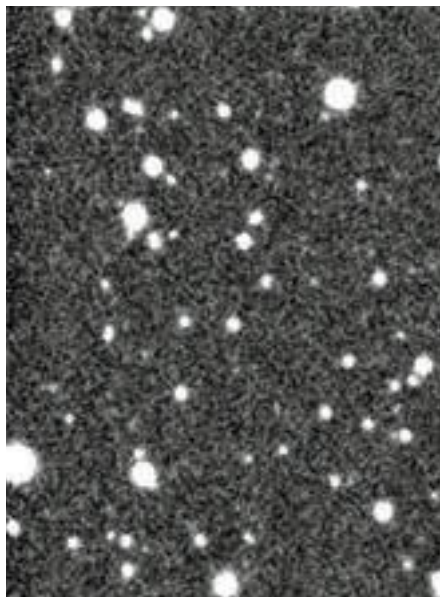
For example, astronomers had believed that the North Polar Hood (or clouds) created by a martian "Indian summer" prevented the formation of a polar cap beneath them. Parker imaged the hood through a red filter and discovered albedo features appearing through the hood. This proves the underlying polar caps form almost instantly as the hood condenses on the planet's surface, which contributes to a much better understanding of polar-cap



MARS IS A FAVORITE TARGET of Donald C. Parker of Coral Gables, Florida. Parker imaged Mars on October 25, 1992, and discovered albedo features (arrows) below the North Polar Hood, indicating the hood condenses to form the ice cap. Parker used a Stansbury 16-inch Newtonian reflector and a LYNXX-PC CCD camera to obtain this image. DONALD C. PARKER



THE PERIOD OF AN EXTRASOLAR PLANET was calculated by repeated observations of the star Tau (τ) Boötis. Tom Kaye of Sonoita, Arizona, used a 16-inch Meade LX200 Schmidt-Cassegrain telescope with an attached spectrograph (a device that breaks light into its component wavelengths) and an Apogee AP7b CCD camera between February 12 and March 5, 2000, to make the observations. TOM KAYE



THE DEEPEST IMAGE taken by an amateur was made by Paul Boltwood of Stittsville, Ontario, Canada. Boltwood used his homemade 16-inch f/4.7 Newtonian reflector and a CCD camera that uses a Thomson-CSF TH7883 scientific-grade, front-illuminated CCD chip to reach a staggering magnitude 24.5 in this image. Stacking 25.5 hours worth of 4-minute exposures, Boltwood's image shows a tiny, star-poor region in the constellation Serpens. PAUL BOLTWOOD

formation overall. Parker was also the first to image the martian dust storm late in July 2003. But his most intriguing discovery is that the polar caps on Mars are shrinking at rates similar to those on Earth. Global warming, it seems, is not confined to Earth.

Of planets and comets

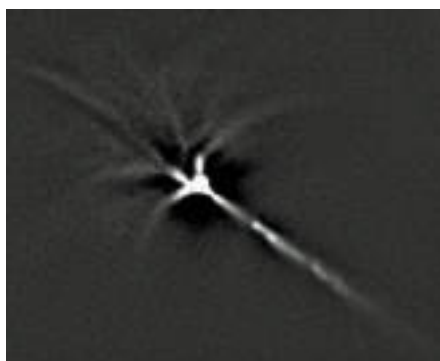
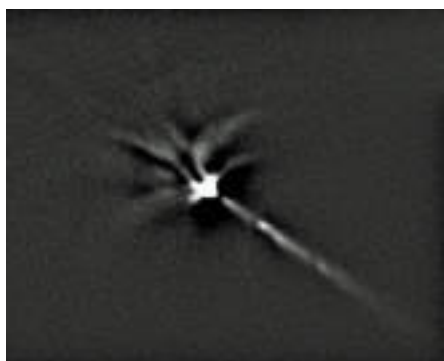
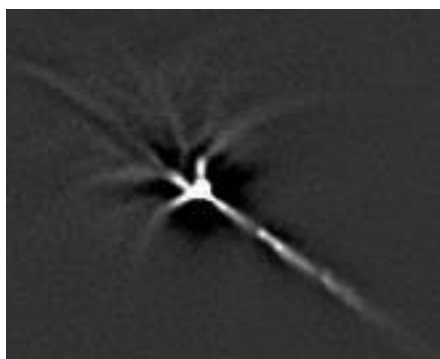
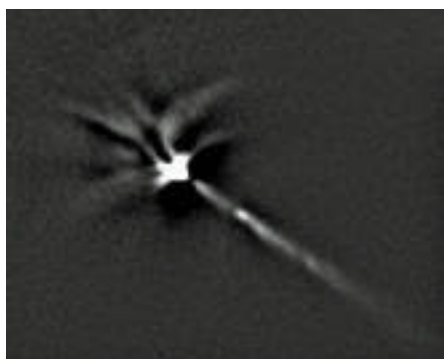
Tom Kaye is the principal investigator heading up a team of amateur astronomers searching for new planets around nearby stars. The team built a spectrograph (a device that breaks light into its component wavelengths) and used a 16-inch Meade LX200 Schmidt-Cassegrain telescope and an Apogee CCD camera to calculate the orbit of a planet circulating the star Tau (τ) Boötis.

Many discoveries have been made by amateurs too tenacious to give in to their body's demand for sleep and/or comfort. A case in point is amateur astronomer Paul Boltwood of Stittsville, Ontario, Canada. He has recorded stars as faint as magnitude 24.5 with his homemade CCD camera and 16-inch f/4.7 telescope. Boltwood stacked 25.5 hours worth of 4-minute exposures to achieve this feat.

In 1996, Boltwood — with fellow Canadian comet investigators Doug George (author of *MaxIm DL*) and Peter Cerevolo — created *Comet Odyssey*, a video that provides stunning images of the forces at work in the tail and nucleus of Comet Hyakutake (C/1996 B2). Boltwood took 2,507 high-resolution images of Comet Hyakutake's nucleus using a 7-inch Astro-Physics refractor and a homemade CCD camera. Boltwood and George then spent countless hours aligning and processing the images. For the first time, jets were seen emanating from a comet's nucleus like a garden sprinkler as Comet Hyakutake rotated. This research was widely acclaimed by astronomers as an outstanding amateur achievement.

Personal goals

I think a wonderfully rewarding way to make personal discoveries with your CCD camera is to image Messier objects such as the Whirlpool Galaxy (M51). Use short exposure times and stack a number of



THE "LAWN SPRINKLER" EFFECT of a comet's nucleus had never before been captured on film until amateur astronomer Paul Boltwood of Stittsville, Ontario, Canada, photographed Comet Hyakutake. These four views were taken from different rotational angles with Boltwood's 7-inch Astro-Physics apochromatic refractor and homemade CCD camera that uses a Thomson-CSF TH7883 scientific-grade, front-illuminated CCD chip. PAUL BOLTWOOD

Jack B. Newton is a world-renowned astrophotographer and manager of Arizona Sky Village in Portal, Arizona.

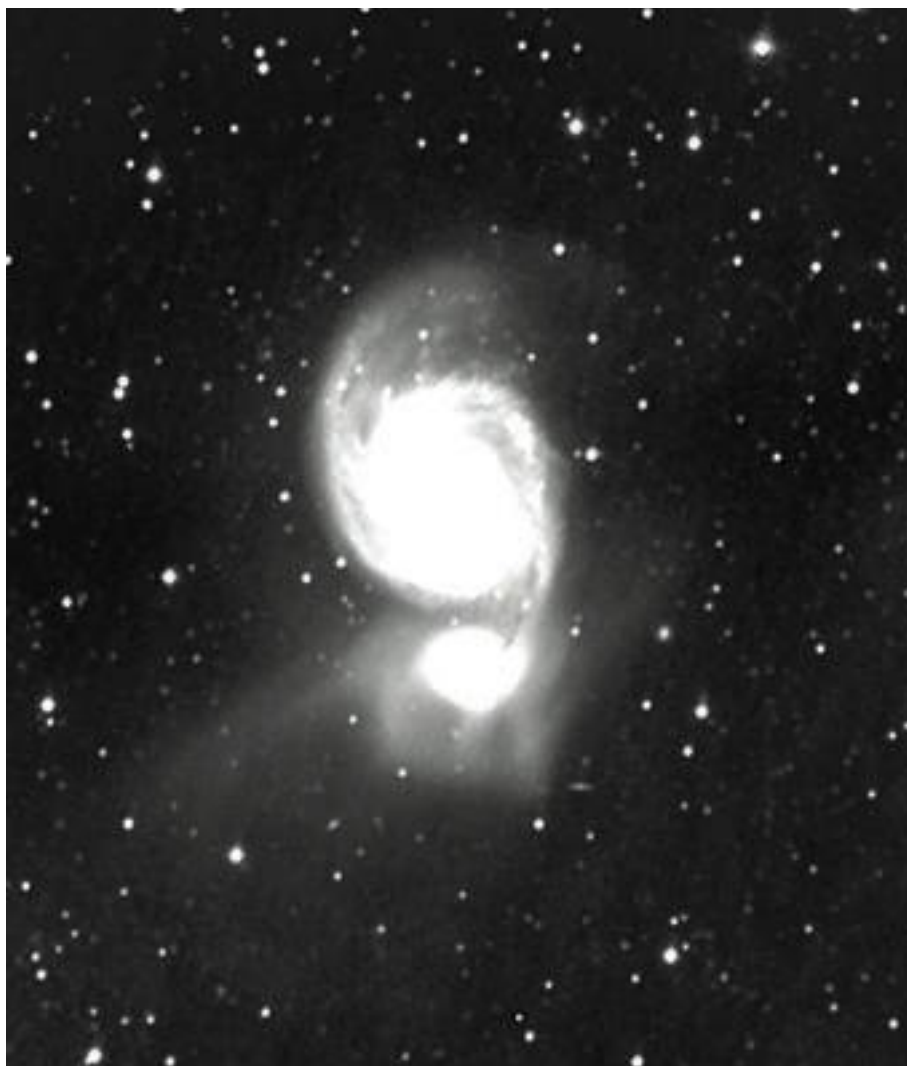
images, then compare your results to other images taken with telescopes from around the world. The last time I imaged the Whirlpool Galaxy with twelve 5-minute exposures that were stacked (to produce one 60-minute image), I was able to record two long spiral arms emanating from the companion. One drifted up the side of the primary galaxy and the other, down and away. I scrutinized the image and compared it to the same region of sky in the digitized Palomar Sky Survey, but I found only traces of the spiral arms on the Palomar image. This type of backyard discovery — finding a new feature in a well-known object — is instantly rewarding.

Each time I see an image taken by the Hubble Space Telescope (HST), I challenge myself to see how well I can image the same object. In the spring of 2003, my heart raced as I viewed HST's extraordinary image of Abell 2218, a lensing galaxy cluster. The massive cluster's gravity bends and focuses light from galaxies that lie behind the cluster at four to five times its distance. My good friend Ajai Sehgal and I made six 10-minute exposures through my Meade 16-inch LX200 at f/10 and then combined them to produce a one-hour image of Abell 2218. I cropped most of the image to match as closely as possible the scale used by HST. Even though this cluster is approximately 2 billion light-years from Earth, and despite less-than-steady air, many of the cluster's galaxies were easily identifiable in a bloated image of the brightest lensed areas.

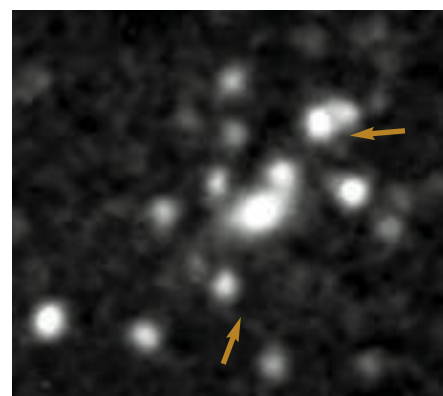
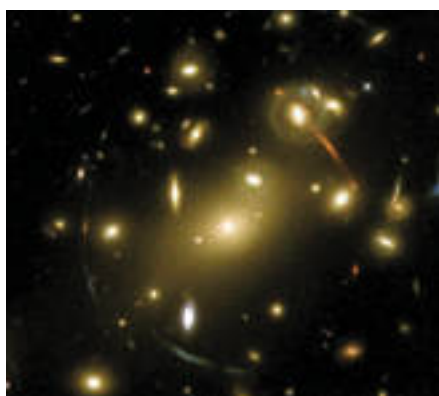
Supernovae and asteroids

Searching with CCD cameras for supernovae in external galaxies is much like a fishing derby, where all contestants scramble to capture the elusive trophy. In this case, however, science is the winner, as several groups of eager astronomers throw their collective energy into imaging thousands of galaxies. Robotic telescopes work through all hours of darkness in observatories worldwide to record the distant, brightening points of light that herald the violent end of red supergiant stars.

Tim Puckett of Elijay, Georgia, started constructing telescopes back in 1978. He quickly became engrossed in the hobby, and he designed and constructed a 24-inch Ritchey-Chrétien telescope with stainless steel belt drives to eliminate the periodic error often introduced by the



SOMETIMES DISCOVERY COMES while imaging well-known objects. Using his Meade 16-inch Schmidt-Cassegrain scope and a LYNXX-PC CCD camera, the author stacked twelve 5-minute exposures of the Whirlpool Galaxy (M51). Clearly seen on the image are two long, spiral arms emanating from the smaller galaxy. One arm drifts up the right side of M51 and the other, down and to the left of it. JACK B. NEWTON



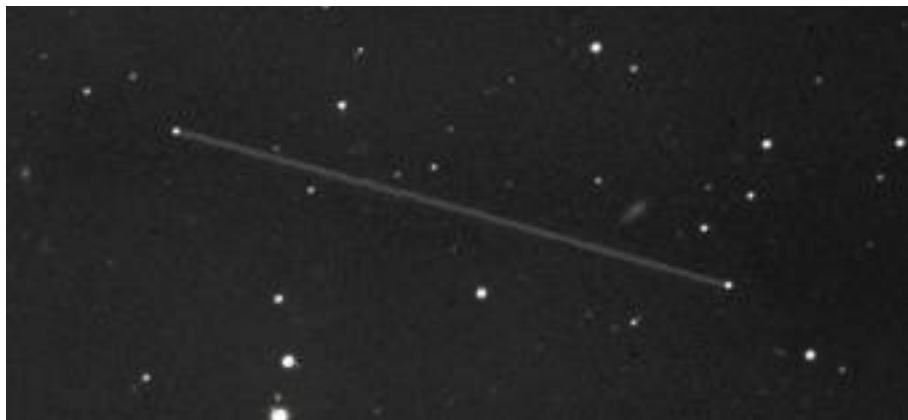
GALAXY CLUSTER ABELL 2218 (left) was imaged by the Hubble Space Telescope on April 5, 1995. Newton and his friend, Ajai Sehgal, took a 60-minute exposure of Abell 2218 (right) with the author's Meade 16-inch Schmidt-Cassegrain telescope and a LYNXX-PC CCD camera and compared their shot to Hubble's. Lensing marks near this cluster, which lies more than 3 billion light-years from Earth, are actually light from a galaxy four to five times more distant than Abell 2218 bent by the immense gravity of the cluster. The arrows in the image on the right show faint traces of the lensing effect in the amateur image. JACK B. NEWTON AND AJAI SEHGAL

worm gears of conventional telescopes. The new telescope weighed a whopping 2 tons but could acquire faint galaxies with pinpoint accuracy. He started searching for supernovae in June 1998.

Puckett developed computer-scripted programs to move the telescope and CCD camera from one galaxy to the next like some cosmic honeybee sampling the starlight and storing the precious images. After dedicating countless hours to setting up the search program, Puckett was rewarded with a supernova in UGC 10432, a 16th-magnitude galaxy in Hercules. He added three more telescopes and, in very short order, realized that personally acquiring and then checking more than a thousand images seven days a week was a pace he could not maintain alone.

Puckett assembled a team of dedicated, sharp-eyed amateurs who could check the images each day. Another necessity is high-speed Internet service, as the lists of objects are very large, and supernova candidates need to be checked against existing databases. Puckett routinely collects between 800 and 1,500 images a night, and these are allocated to team members in blocks of several hundred each.

One of the earliest members of the supernova search team, Ajai Sehgal, wrote a computer program called a “blinking engine” that loads two image sets simultaneously — one set of newly acquired images and another, older set from a stored database. Two images appear on the screen side by side and, with a mouse-click, align themselves one atop the other. By blinking the two images (aligning both images on the computer monitor and then viewing them in rapid succession),



ASTEROID HUNTING requires imaging the same spot in the sky twice, with exposures taken approximately 5 minutes apart. A “blink” comparison then shows the asteroid’s movement. Asteroid 2002 NY₄₀, which has a diameter of about 1,600 feet (500 meters), sped by Earth at a distance of only 227,000 miles (363,000 kilometers) on the nights of August 17 and 18, 2002. Two 1-minute superimposed exposures show the large motion (indicated by the gray line) of this object. JACK B. NEWTON

any supernova suspects can be detected quickly and checked against the Internet’s digitized Palomar Sky Survey database to ensure a faint star has not been mistaken for a supernova. A second database is then checked to identify any asteroids in the image at the time of the exposure. A final check of recent supernova discoveries is made, and when a suspect is not present in the database, the excitement becomes palpable. Soon thereafter, a re-shoot must be done to confirm or negate the suspect.

In the event that bad weather in Georgia prevents Puckett from arranging a re-shoot at first nightfall, I get to do the honors from my observatory either in British Columbia or at the Arizona Sky Village in Portal. Puckett’s supernova search program has been in existence for only five years, and already it has made 78 supernova discoveries. I’ve been privileged

to have worked on Puckett’s team, blinking thousands of images, for more than three years, and I’ve been rewarded with the codiscovery of five supernovae.

Patient amateurs also can track and discover new asteroids. The trick is to image the night sky where asteroids are at their brightest — opposite the Sun, where they are completely illuminated like the Full Moon. This point is on the ecliptic and is 12 hours in right ascension from the Sun. I reverse the Sun’s declination, point my telescope to that area of the sky, and set my CCD camera to take either a 1-minute or 2-minute exposure. I then wait for about 5 minutes and re-shoot the same field. Finally, I use *MaxIm DL* to blink the two images. It’s interesting to note that the blinking of astrophotographs has been done for many years and has accounted for hundreds, if not thousands, of asteroid, comet, and supernova discoveries.

Few fields of study exist, especially in science, where an amateur can make meaningful contributions. Imagine the odds of making a discovery in practical physics or molecular biology from your garden shed. Where other fields limit your ability to all but dabbling, astronomy remains one area where you always stand a chance of making a discovery. The sky gives everyone equal access to all the data. Telescopes equipped with CCD cameras are the vehicles to take you to the “outer limits” and then provide proof that you’ve been there. Happy discoveries, everyone! ■



DISCOVERING SUPERNOVAE is the first step in understanding the violent deaths of massive stars. Together with principal investigator Tim Puckett, coinvestigators on the Puckett Observatory Supernova Search Team of amateur astronomers have discovered 78 supernovae. Supernova 2003J was discovered in spiral galaxy NGC 4157 by Puckett, Reiki Kushida, and the author. Compare a digital Palomar Sky Survey image (left), which does not show the supernova, to the author’s image (right), taken with his Meade 16-inch Schmidt-Cassegrain telescope and LYNXX-PC CCD camera. At maximum, the supernova rose to only magnitude 17.5. LEFT: SLOAN DIGITAL SKY SURVEY; RIGHT: JACK B. NEWTON



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Home of the expanding universe, the discovery of Pluto, and a cow named Venus, Lowell Observatory sustains its rich legacy of discovery. /// BY DAVID HEALY

A visit to Mars Hill

The past and future of astronomical observing enjoy a harmonious relationship on Mars Hill, home of Lowell Observatory, just outside Flagstaff, Arizona. Astronomy enthusiasts flock to this location to see the famous, aged chair where Percival Lowell sat for hours searching unsuccessfully for his “Planet X,” and where,

according to legend, his ghost continues to scour the skies for that phantom planet. They come to see the instruments responsible for so many historical discoveries: the 24-inch Alvan Clark refractor used by Vesto Melvin Slipher to discover the expansion of the universe; the blink comparator used by Clyde Tombaugh to discover Pluto; and the equipment currently scanning the sky for asteroids. On June 17, 2004, the second annual Lowell Star Party will kick off, immersing participants into the rich history and exciting future of the famous Lowell Observatory.

Expanding the universe

On the night of December 28, 1912, V. M. Slipher began a long-exposure photograph of the spectrum of M31, the great “spiral nebula” in the constellation Andromeda. He used the Alvan Clark 24-inch refracting telescope at Lowell Observatory and the Brashear spectrograph, which he had spent eleven years refining. The image was exposed for a total of 20 hours spanning three separate nights, concluding only in the first hours of the year 1913.

Until that landmark photograph, most scientists believed spiral nebulae were solar systems forming in our own Milky Way. Thanks to Slipher’s pioneering photo-

David Healy is a contributing editor of *Astronomy*. He fled New York nine years ago to establish a private observatory under the dark skies of southeastern Arizona.



PERCIVAL LOWELL (1855–1916)

LOWELL OBSERVATORY ARCHIVES

graphs of their spectra, we now know spiral nebulae are island universes millions of light-years away. We also know these spirals rush away from us at speeds proportional to their distances, indicating the expansion of the universe.

Although astronomer Edwin Hubble is generally credited with discovering the expansion of the universe, Hubble used Slipher’s measurements of galactic redshifts to plot the distance/velocity relationship that convinced most astronomers the universe was indeed expanding. Referring to Slipher’s 1912/1913 measurement of Andromeda’s radial velocity (in this unusual case a *blueshift* indicating the galaxy was approaching), Hubble, not

noted for praising other astronomers’ work, wrote, “I regard such first steps as by far the most important of all. Once the field is opened, others can follow.”

From Boston to Flagstaff

Slipher was one of a small group of professional astronomers recruited by wealthy Boston patrician and amateur astronomer Percival Lowell (1855–1916) to staff Lowell Observatory. Starting in 1894, Lowell built and equipped the observatory with his own funds under the clear and steady skies above a hilltop just west of Flagstaff, Arizona, the site now known as Mars Hill.

Lowell is famous, or more accurately notorious, for his insistence that Mars is a dying planet whose inhabitants dug irrigation canals to distribute a diminishing water supply to their farms and cities. Regarded by most of his contemporary astronomers as a dilettante and a fabulist, Lowell also promoted a number of lesser known, but equally incorrect, theories such as the existence of visible “spokes” on Venus and the existence of a giant “Planet X,” which according to his calculations, perturbed slightly the orbits of Uranus and Neptune.

Astronomers at the observatory didn’t resume the search for a ninth planet until after Percival Lowell’s death. After recovering from a long, debilitating, and costly legal battle with Lowell’s widow surrounding details of Lowell’s will, the observatory and its staff renewed its commitment to finding Lowell’s Planet X. In the late 1920s, the observatory hired a “young man from Kansas,” Clyde Tombaugh, to renew the search for Planet X.



PERCIVAL LOWELL reclines to observe through the Alvan Clark 24-inch refractor. V. M. Slipher used this scope to gather the first evidence of our expanding universe.

LOWELL OBSERVATORY ARCHIVES

/// WHEN THE BOSS IS AWAY...

Percival Lowell suffered from intermittent bouts of depression, which accounted for some of his prolonged absences from the observatory. When these absences corresponded with periods when Mars or other planets were poorly situated for observation, Lowell encouraged his professional staff to pursue extra-solar-system research with the observatory's state-of-the-art equipment. V. M. Slipher studied galactic spectra and made one of the greatest discoveries in the history of science using a telescope intended primarily for the visual observation of Mars.

Nonetheless, Slipher was not entirely free for research when Mars or Lowell were out of sight. Slipher received numerous letters from Boston full of detailed instructions for taking care of the observatory's cow, Venus, and her calf, Satellite.



THE SLIPHER BUILDING originally served as the administration center for Lowell Observatory. Built around 1915, the building rotunda now houses the Lowell Observatory Library.

LOWELL OBSERVATORY ARCHIVES



THE 24-INCH CLARK REFRACTOR is used today by the Observatory's public program as a portal to astronomy for thousands of visitors annually. LOWELL OBSERVATORY



dark given its location only a mile from downtown.

Equipment at Anderson Mesa includes five telescopes with apertures as large as 72 inches and an optical interferometer. As has been true throughout its history, the observatory concentrates its astronomical research on the solar system, including Pluto, Jupiter's moon Io, and, particularly, asteroids and trans-Neptunian objects. Indeed, the observatory is probably best known today for its research and resources on asteroids, notably the Lowell Observatory Near-Earth-Object Search (LONEOS). To date, LONEOS has made more than two million asteroid observations and discovered 169 near-Earth-approaching asteroids and 16 comets.

THE 13-INCH A. LAWRENCE LOWELL TELESCOPE

was used by Clyde Tombaugh in 1930 to discover Pluto. It is now part of the guided tour [inset] of Lowell Observatory. LOWELL OBSERVATORY ARCHIVES

The Pluto connection

Although Slipher uncovered the first evidence of the expansion of the universe at Lowell, the observatory is more famous as the site of Tombaugh's 1930 discovery of Pluto, the ninth planet.

The fact that Pluto was discovered in more or less the same region of the sky as forecast by Lowell for Planet X was, sadly, just a coincidence. Pluto, it turns out, is too minuscule to perturb the orbit of

Uranus or Neptune. A debate among astronomers (mostly over terminology, it seems) continues to rage today about whether Pluto is a very large trans-Neptunian object or a very small planet.

Mars Hill today

Lowell Observatory remains a private institution and still derives a significant portion of its funding from a trust set up in Percival

Lowell's will. Observing (but not astronomical research) has moved "off campus," to the dark Anderson Mesa site, as light pollution from the growing city of Flagstaff reduces the utility of the original Mars Hill location. Nonetheless, an aggressive and successful anti-light pollution campaign led by Chris Luginbuhl of the United States Naval Observatory in Flagstaff has kept Mars Hill surprisingly

Come one, come all

Mars Hill remains a prime destination for the astronomy-minded tourist. The 24-inch Clark refractor, originally installed in 1896 and through which Slipher detected his (real) galactic redshifts and Lowell saw his (imaginary) martian canals, is open for public observing and can be reserved for groups large or small. The author's lifetime best view of Mars was achieved through the Clark during the planet's close approach in the summer of 2003; the only disappointments were that he saw neither martian canals nor Percival Lowell's ghost. Percy's shade, according to lore, can be glimpsed occasionally in the wee hours of the night seated in his wooden observing chair, which is still at its original place in the dome. Actually, Lowell's body lies next to the dome housing the Clark refractor in a highly decorated mausoleum that his widow exhausted the observatory's endowment to finance — an outlay of about \$800,000 in today's dollars.

Tombaugh's scope and more

The 13-inch telescope through which Clyde Tombaugh exposed his Pluto discovery plates also is accessible to visitors during daytime, public tours. A path leading to the Pluto Discovery Telescope's dome is laid out as a scale model of the solar system. The path begins at a model of the Sun and ends at a model of Pluto, located appropriately next to the entrance to the telescope's dome. These tours (several daily) originate from the Steele Visitor



HAND-PAINTED MARTIAN GLOBES reveal Percival Lowell's interpretations of the Red Planet's surface. Lowell published several books on his theory of life on Mars. He believed the presence of "canals" was evidence of intelligent beings on Mars.

LOWELL OBSERVATORY ARCHIVES/COLEMAN-KENNEDY COLLECTION

Center, which houses exhibits relating to both astronomy, in general, and the history of Lowell Observatory, in particular, as well as a gift shop and video theater.

Near the visitor center is the Rotunda Library. Once Percival Lowell's library, it is now a fine, small museum. Lining the wall are Lowell's ancient astronomical tomes and several of his hand-painted martian globes, of course streaked with canals. The blink comparator that Clyde Tombaugh used to detect the motion of Pluto against the background stars in the constellation Gemini sits to one side of the main gallery. It is still in working order, and visitors can operate the mechanism and watch the image of Pluto hop back and forth on copies of Tombaugh's original 1930 photographic discovery plates.

The most impressive pieces of the library's exhibits lie across the gallery from Tombaugh's blink comparator: the Brashear spectrograph and Slipher's tiny glass photographic plate, which shows spectral lines of the Andromeda spiral shifted sharply to blue. The blueshift indicates the spiral is approaching us at the rate of about 200 miles (320 kilometers) a second, a velocity far higher than any ever measured before 1913.

Visiting the Lowell Observatory

Lowell Observatory and Flagstaff are located in north-central Arizona near the junction of Interstates 40 and 17, about 135 miles north of Phoenix. Flagstaff is home to Northern Arizona University and offers hotels and motels in all price ranges, many of them belonging to national chains. Lowell Observatory is no more than a ten-minute drive from central Flagstaff. Mars Hill's elevation is 7,260 feet, and visitors from sea level may become winded walking around the grounds. Fortunately, management has thought to scatter benches throughout the observatory site. Given its elevation and latitude, Flagstaff winters can be harsh — don't expect Phoenix weather on Mars Hill. Visitors intent on observing with the Clark refractor might well avoid the months of July and August — Arizona's monsoon season generates numerous cloudy nights. Meteor Crater, another magnet for the astronomical tourist, is about an hour's drive east of town.

Percival Lowell was an amateur astronomer, and his observatory now



THE ROTUNDA of the Slipher building is a museum open to the public. Among the collection are the spectrograph used by V. M. Slipher to discover the expanding universe, the Zeiss blink comparator used for spotting Pluto, as well as Lowell's martian globes. LOWELL OBSERVATORY

relies significantly on public contributions. Perhaps for these reasons, Lowell Observatory is a most user-friendly institution. Public outreach programs include not only tours of the facilities and use of the 24-inch refractor, but also observing and lecture programs both on-site and off. Lowell Observatory's phone number is 928.774.3358. Schedules of tours and other detailed information about the observatory can be found on its web site: www.lowell.edu. ■



To learn more about Lowell discoveries, visit www.astronomy.com/toc



MARS HILL, as viewed from above, is located just west of Flagstaff, Arizona. The Clark telescope dome is visible on the right. LOWELL OBSERVATORY

/// FUTURE FULL OF DISCOVERY

Lowell Observatory likely will regain its stance on the cutting edge of astronomical research with the start-up in 2008 of the \$30 million Discovery Channel Telescope (DCT), a versatile 4.3-meter (160-inch) instrument that will be capable of imaging an extremely wide area of the sky for its aperture. The new scope probably will be built at a new, dark site near Happy Jack, Arizona, about 40 miles southeast of



Flagstaff. At "prime focus," the DCT will be able to image an area of the sky 16 Full Moons (8°) wide and will detect objects more than forty million times fainter than can be seen by the unaided eye. With other instrumentation attached, the DCT will be capable of spectroscopy and imaging in the near-infrared, making it effective during bright phases of the Moon and also for real-time broadcast of its observations.

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DSLR shown on a Canon 100D

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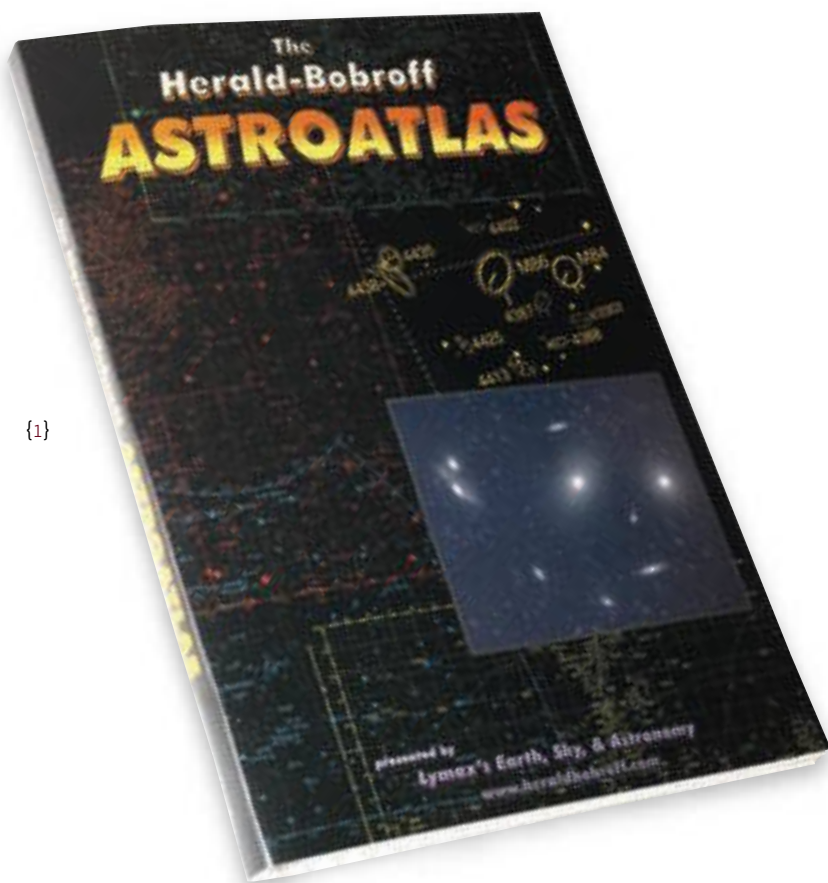
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Mars continues to be in the news, and Space.com's *Eyes on Mars* DVD will help you keep up with the latest. In addition to a documentary, also included are a look at Mars missions of the past, a 3-D computer-generated simulation of current missions to Mars by the United States, a Mars gallery with artists' renderings of martian landscapes, and interviews with experts.

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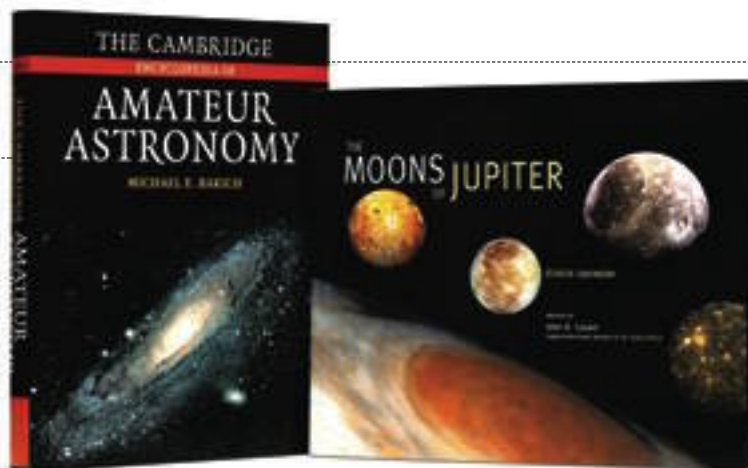
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A fine guide to skygazing



The Cambridge Encyclopedia of Amateur Astronomy

Michael E. Bakich, 354 pages, Cambridge University Press, New York, 2003; ISBN 0-521-81298-4; hardcover, \$60.

This book is Michael Bakich's third, following guides to constellations and planets. Like those books, this one is a valuable and well-organized guide for anyone skygazing with a telescope or binoculars.

The opening chapter surveys the cosmos, starting with Earth, the Moon, inner and outer planets, and finally the stars. Positional astronomy, timekeeping, and the calendar follow. The section on observing equipment caught me up in a detailed discussion of filters and where they work best. I especially like the exhaustive account of the effects of different filters on 84 popular deep-sky objects.

Chapters follow on observing techniques, astrophotography, books, sky atlases, and software. Bakich covers a lot of subjects — including home observatories. In fact, few topics, recent developments, or pieces of amateur astronomical equipment escape being touched on in this book.

Encyclopedias often have lots of pictures, and this book is no exception — good photos and illustrations are plentiful. Bakich put out a worldwide call to amateur astronomers for images, and the results are stunning.

I had just one complaint: Spotchecks of Internet references showed some web sites have already gone dead. I wish the publisher or author had created a reference web site for updating the links. But that quibble aside, this is an excellent reference guide for amateur astronomers.

— **BRUCE BERGER** is a member of the *Amateur Telescope Makers of Boston* and a long-time skywatcher.

The Moons of Jupiter

Kristin Leutwyler, 240 pages, W. W. Norton, New York, 2003; ISBN 0-393-05060-2; hardcover, \$39.95.

The Moons of Jupiter is a coffee-table book that aims to showcase the 8-year-long Galileo mission to Jupiter and the wonders it found. Unfortunately, the book suffers from labored writing, poor editing, sloppy proofing, and scientific misconceptions.

Errors range from typographical mistakes (Comet Shoemaker-Levy 9 hit Jupiter in 1994, not 1944) to misrepresented reality (the Hubble Space Telescope has never gone to Jupiter).

Several stylistic difficulties plague the writing. The first is forced comparisons between features on the jovian moons and stories of their mythological namesakes. Some parallels exist due to naming conventions — volcanoes on Io are named after figures relating to fire. But Leutwyler often relates myths that help little in understanding geological features.

Second, most of the images do not indicate the features discussed, requiring long descriptions of the scene so the reader can spot the feature. Adding arrows to the images would help a lot. The third problem is a wildly varying level of knowledge assumed in the reader. We get rudimentary descriptions of volcanic features on Io *and* discussions of the triple-bonds between carbon and nitrogen.

This book seems rushed through production to hit the shelves at the end of the mission. My advice is to go to the Galileo web page, where you can see the same images and read descriptions written by the mission scientists themselves. ■

— **EDWARD BIERHAUS** recently got a Ph.D. in planetary science (focusing on impact craters) from the University of Colorado.



A Traveler's Guide to Mars

William K. Hartmann, 468 pages, Workman Publishing, New York, 2003; ISBN 0-7611-2606-6; paperback, \$18.95. If anyone should write a guidebook to Mars, it's planetary scientist Bill Hartmann. He's been involved in martian studies since early in the space age. This almost-pocketable book gives the ordinary reader a well-illustrated overview of Mars, its history, and how it "works" as a planet. In addition, sections titled "My Martian Chronicles" let Hartmann talk about his personal experiences and thoughts on the subject of Mars exploration. The book's handy size makes you wish for a larger page to see the images better.

The Rocket Team

Frederick I. Ordway III and Mitchell R. Sharpe, 324 pages, Apogee Books, Burlington, Ontario, 2003; ISBN 1-894959-00-0; hardcover, \$34.95. This is a republication, with important extras, of a history first published in 1979. The text tells of the German rocket engineers who developed the V-2 missile and brought advanced rocket engineering to the United States after 1945. Working in the U.S., the team created the giant booster rockets that launched men to the Moon. (The main narrative, however, ends in about 1960.) The new edition includes a DVD with movies of rocket launches from the 1920s to the 1960s, including color footage of V-2 launches. Also on the DVD are two lectures on space flight by rocket team leader Wernher von Braun.

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NEXT MONTH

Jupiter's water worlds

The Galileo spacecraft's observations of Europa, Ganymede, and Callisto show these giant moons likely possess large subsurface oceans of liquid water.

Earth and its Moon

Earth and the Moon are indeed a "double planet," but not the way some think. Both celestial bodies are leftovers from an early collision between protoplanets.

Moon landing a hoax?

Some TV programs and web sites claim the whole episode was an elaborate hoax. If you're at all unsure, you should read this story as *Astronomy* weighs in with the facts, putting any doubts to rest.

Ultra deep field

Astronomers using the Hubble Space Telescope have just released the deepest visible-light image of the cosmos.

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06.14.04–06.20.04

Almost heaven . . . West Virginia.

Amateur astronomers from the United States and Canada will express the same sentiments as John Denver when they descend upon the Mountain State this summer for a multitude of astronomical gatherings. Among these events is



THE SUMMER MILKY WAY offers a rich bounty of targets for late spring and early summer star party attendees to reacquire themselves with the night sky. FRANK ZULLO

the Laurel Highlands Star Cruise held at the Pine Hill Campground, Hazelton, West Virginia.

The sixth annual event will feature standard star party activities, including observing, lectures, workshops, extended children's activities, a model rocket launch, a swap table, and door prizes.

Making a special appearance at Laurel Highlands is the NASA Glenn-Lewis Research Center Aerospace Bus. This mobile facility travels to various events throughout the country, providing educational displays of space science.

For more information, e-mail, jmholtz@aol.com; web site, www.lhstarcruise.org.

06.12.04–06.19.04

Grand Canyon Star Party

North and South Rims, Grand Canyon National Park, Arizona. The National Park Service and the Tucson Amateur Astronomy Association will host the 14th

Grand Canyon Star Party. For this public event, amateur astronomers volunteer their scopes for visiting tourists to observe the night sky from one of the nation's darkest sites. For more information, visit www.tucsonastronomy.org/gcsp.html.

06.18.04–06.19.04

National Symposium on Teaching Astronomy for Non-science Majors

Tufts University, near Boston. This conference will focus on how research results about student learning can be applied in classrooms; how to address the needs of under-served groups; and alternative teaching methods. For more information, visit www.astrosociety.org/events/cosmos.html.

07.08.04–07.11.04

Green Bank Star Quest

Green Bank National Radio Astronomy Observatory, Green Bank, West Virginia.

Cosponsored by the Central Appalachian Astronomy Club and the Kanawha Valley Astronomical Society of West Virginia, this event includes observing, imaging, NRAO tours, lectures, contests, and use of a 40-inch dish (for a limited number of pre-registrants). Enjoy the night sky in the radio quiet zone of West Virginia. For more information, contact Joe Gonzalez at 304.626.5012; web sites, www.caacwv.org and www.KVAS.org.

07.13.04–07.19.04

The Mountain Institute Summer Astronomy Camp

The Spruce Knob Mountain Center, near Franklin, West Virginia. For 7th through 12th graders, this week-long camp lends youngsters an opportunity to see the stars from a high altitude and to visit the National Radio Astronomy Observatory. Activities during the day will include natural science and astronomical studies. For more information, visit www.mountain.org/skmc/index.html.

07.15.04–07.18.04

Mountain Astronomers Rendezvous and Star Party

Grand Mesa, near Grand Junction, Colorado. Hosted by the Western Colorado Astronomy Club, this is the 15th annual gathering. Located at an elevation of 10,600 feet (3,232 m), light pollution will not be an issue. For more information, contact MARS registration, P. O. Box 55032, Grand Junction, CO 81505; phone, 970.242.1721; e-mail, regiaero@acsol.net; web site, www.coloradowestastronomy.org/SP04.html.

07.16.04–07.18.04

Susquehanna Summer Star Spectacular

Pine Grove Furnace State Park, near Newville, Pennsylvania. Some changes have been made since the previous star party, including the addition of a 24-hour food service and a site featuring a darker sky. For more information, contact Ted Nichols II at 717.856.3851; e-mail, president@astrohbg.org; web site, www.s4starparty.org.

07.16.04–07.17.04

Arkansas Star Party

Devil's Den State Park, West Fork, Arkansas. This observing weekend, hosted by the Arkansas-Oklahoma Astronomical Society, will have camping rentals and groceries on-site. For more information, visit www.aos.org.

07.17.04–07.20.04

CCD Workshop Weekend

National Optical Astronomy Observatory, Tucson, Arizona. Learn how to produce stunning images of deep-sky objects from Adam Block, head of the Advanced Observer's Program at Kitt Peak National Observatory. The organizers ask that participants bring a laptop computer equipped with image-processing software. For more information, visit www.noao.edu.

07.20.04–07.23.04

Island Star Party

The Victoria Fish and Game Association site, near Victoria, British Columbia, Canada. Hosted by the Cowichan Valley StarFinders, this event features observing, lectures, and guided nature walks. For more information, visit starfinders.cvnet.net/home.htm.

08.14.04–08.15.04

Toledo Astronomical Association Summer Star Party

Pioneer Scout Reservation, Pioneer, Ohio. Bringing in astronomers from Ohio, Michigan, and Indiana, this event celebrates the relocation of TAA's 25-inch scope. For more information on this exciting event, e-mail Don Murad at dmurad@uofto2.utoledo.edu or Alan White at alanwhite@acsitoleado.com. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our on-line calendar.

INDEX of ADVERTISERS

ASM Products	99
Adorama	72, 73
Anacortes Telescope and Wild Bird	23
Analytical Scientific	100
Astro Haven	97
Astro Physics	97
Astronomics	64-65
Astronomy Magazine	18-19, 94
Astronomy Magazine Tours	72, 89
Atomic Time	97
Beam of Light Technologies	98
Berger Brothers Camera	100
Beta Electronics	100
Bethany Sciences	100
Birders' World Magazine	83
Bubba's Bits, Inc.	100
Camcor, Inc.	89
Celestron	51, 52, 57, 58
Coronado Technology Group	17
Dark Sky, Inc.	100
Denkmeier Optical	98
Digitec Optical	99
Equatorial Platforms	98
Explore the Universe 2005	91
Focus Camera	30-31
Glatter, Howard	101
Hands on Optics	97
Hutech Corporation	89
Ideal Astronomy	99
Into the Wind/The Kite Source	98
Jim's Mobile Industries	27
Kansas Wind Power	98
Lumicon	11
Marketplace Pages	98-101
Meade Instruments Corp.	2, 3, 7, 8, 9, 108
New Mexico Skies	99
North Sheds	98
Observatory, Inc., The	99
Oceanside Photo & Telescope	29
Orion Telescopes & Binoculars	20-21, 107
Particle Wave Technologies	98
Pegasus Optics	100
Pixsoft, Inc.	99
ProAstronomer	98
Rainbow Symphony	98
Ritz Camera Superstores	98
Rivers Camera Shop	89
Royal Cruise Adventures	99
SCS Astro	98
SAC Imaging Systems	100
Scope City	15
Scope Stuff	99
ScopeTronix	88
Shutan Camera & Video	15
Sirius Observatories	101
Sky Watchers Inn	97
Smartcase Designs	98
Software Bisque, Inc.	13
Starmaster Portable Telescope	99
Starry Night	101
Stellar Vision	100
Stellarvue	99
Stephen L Gellar, Inc.	93
T & T Binocular Mounts	99
Technical Innovations	101
Telescope Warehouse, The	100
Website Directory	96
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{ FURTHER READING }

RESOURCES

Learn more about this issue's topics:

CHASING THE SHADOW OF VENUS

BOOKS — *The Transit of Venus: The Quest to Find the True Distance of the Sun* by David Sellers (Maga Velda Press, Leeds, England, 2001) is a well illustrated and engaging introduction to Venus transits. Another excellent look at the five previously recorded transits and the personalities of the astronomers who observed them is *June 8, 2004: Venus in Transit* by Eli Maor (Princeton University Press, Princeton, 2000).

WEB — One of the most extensive overviews of Venus transits is located at www.transitofvenus.org/. For details on NASA's Kepler mission and its quest to discover Earth-like planets around other stars, visit www.kepler.arc.nasa.gov/.

RECLAIM THE NIGHT SKY

BOOKS — Check out *Light Pollution: Responses and Remedies* by Bob Mizon (Springer, New York, 2002) for a look at how lighting affects the night-sky experience and to find practical approaches for abatement. Mizon also gives a list (with simple finder charts) of one hundred deep-sky objects worth looking at under moderately light-polluted skies.

WEB — The world maps used in the story came from www.lightpollution.it/dmsp/, a site that publicizes the worldwide problem of light pollution. The International Dark-Sky Association has a web site at www.darksky.org/, where you'll find sample good-lighting ordinances, facts and figures, and everything you'll need to make a difference.

GENESIS PLANET

ARTICLE — The paper that first elucidated the existence of the so-called genesis planet as the third member of a system that includes a pulsar and a white dwarf was "A Young White Dwarf Companion to Pulsar B1620-26: Evidence for Early Planet Formation" by Steinn Sigurdsson, et al. (*Science*, July 11, 2003).

WEB — For a listing of all the extrasolar planets known, go to exoplanets.org/. The site also includes details of the various search methods, characteristics of the planets, and some of the controversies surrounding the definition of a planet.

VIEWING VENUS IN TRANSIT

WEB — A great resource for information on observing the June 8, 2004, transit is sunearth.gsfc.nasa.gov/eclipse/transit/TV2004.html. Here, Fred Espenak and Jay Anderson — renowned for their detailed solar-eclipse predictions — explain the event, map the regions of visibility, describe the weather prospects, and provide extensive tables giving local circumstances for viewing the transit.

AMATEUR CCD DISCOVERIES

WEB — Find out more about how the orbital period of a planet around the star Tau (τ) Boötis was determined at www.spectrashift.com. The Puckett Observatory Supernova Search Team, a dedicated group of amateur astronomers hunting for supernovae, also maintains a web site at www.cometwatch.com/search.html with details about their search process.

A VISIT TO MARS HILL

BOOKS — For a comprehensive history of Lowell Observatory, read William Lowell Putnam's *The Explorers of Mars Hill: A Centennial History of Lowell Observatory, 1984-1994* (Phoenix Publishing, West Kennebunk, Maine, 1994). Visitors to the observatory can pick up Rose Houk's illustration-laden overview, *From the Hill: The Story of Lowell Observatory* (Lowell Observatory, Flagstaff, Arizona, 2nd edition, 2000), on-site.

WEB — Visitor information for the observatory is posted at www.lowell.edu/Public/Info. See the design and learn about plans for the 4-meter Discovery Channel Telescope at Lowell Observatory at www.lowell.edu/dct/dct.php. ■

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SPIRAL GALAXY M66 IN LEO (20-inch RC Optical Systems Ritchey-Chrétien reflector at f/8.4, SBIG ST-10XME CCD camera, LRGB image with exposures of 85, 20, 20, and 20 minutes, respectively, taken January 18, 2004)

/// **JEFF HAPEMAN AND ADAM BLOCK**

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Top, THE PLEIADES (M45) AND GALAXY UGC 2838 [arrow] (4-inch Takahashi FS102 at f/6, DTA Chroma 6303E CCD camera, LRGB image with exposures of 35, 10, 10, and 10 minutes, respectively, taken February 24, 2004) /// **PAOLO CANDY**

Bottom, MARE SERENITATIS [14-inch Celestron Schmidt-Cassegrain telescope at f/2.6, Nikon Coolpix 995 digital camera, $\frac{1}{30}$ -second exposure, taken October 15, 2003, at 3h33m UT from Athens, Greece] /// **ANTHONY AYIOMAMITIS**



Left, THE MOON, VENUS, AND THE EMPIRE STATE BUILDING (Nikon FM2 35mm camera, 200mm lens at f/5.6, Kodak Elite 100 film, 10-second exposure, taken February 23, 2004, at 9:00 P.M. EST from New York, New York) /// **RICH SCARPITTA**



Top right, THE HELIX NEBULA (NGC 7293) IN AQUARIUS (12.5-inch Optical Guidance Systems Ritchey-Chrétien reflector at f/7, Finger Lakes Instruments IMG1024S CCD camera, RRGB image with exposures of 10 minutes for each color) /// **ROBERT GENDLER**



Bottom right, STAR TRAILS AND A PERSEID METEOR (Pentax K1000 35mm camera, 50mm SMC Pentax M lens at f/22, Kodak ISO 100 film, 45-minute exposure from 11:00 to 11:45 P.M. CDT taken August 15, 2002, from Monroe County, Wisconsin) /// **RYAN LETTERLY**



Above, **LARGE SUNSPOT GROUPS** (3.5-inch Questar Maksutov telescope, Nikon 5400 digital camera at $f/23$, $\frac{1}{500}$ -second exposure, taken October 30, 2003. *Inset*, same equipment, $\frac{1}{125}$ -second exposure at $f/65$) /// **ROBERT M. SANDY**



Below, THE GUM 1 NEBULA (IC 2177) {4-inch Takahashi FSQ apochromatic refractor at f/5.3, SBIG ST-10XME CCD camera, two-pane mosaic, each with red, green, and blue exposures of 60, 20, and 32 minutes, respectively, taken February 1, 2003, from Oceanside, California} /// DANIEL B. PHILLIPS



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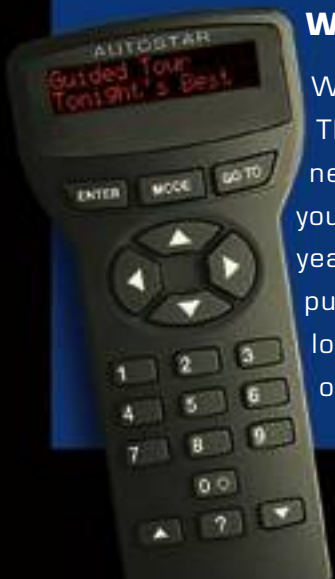


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